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The Marine Engineer

AND NAVAL ARCHITECT.

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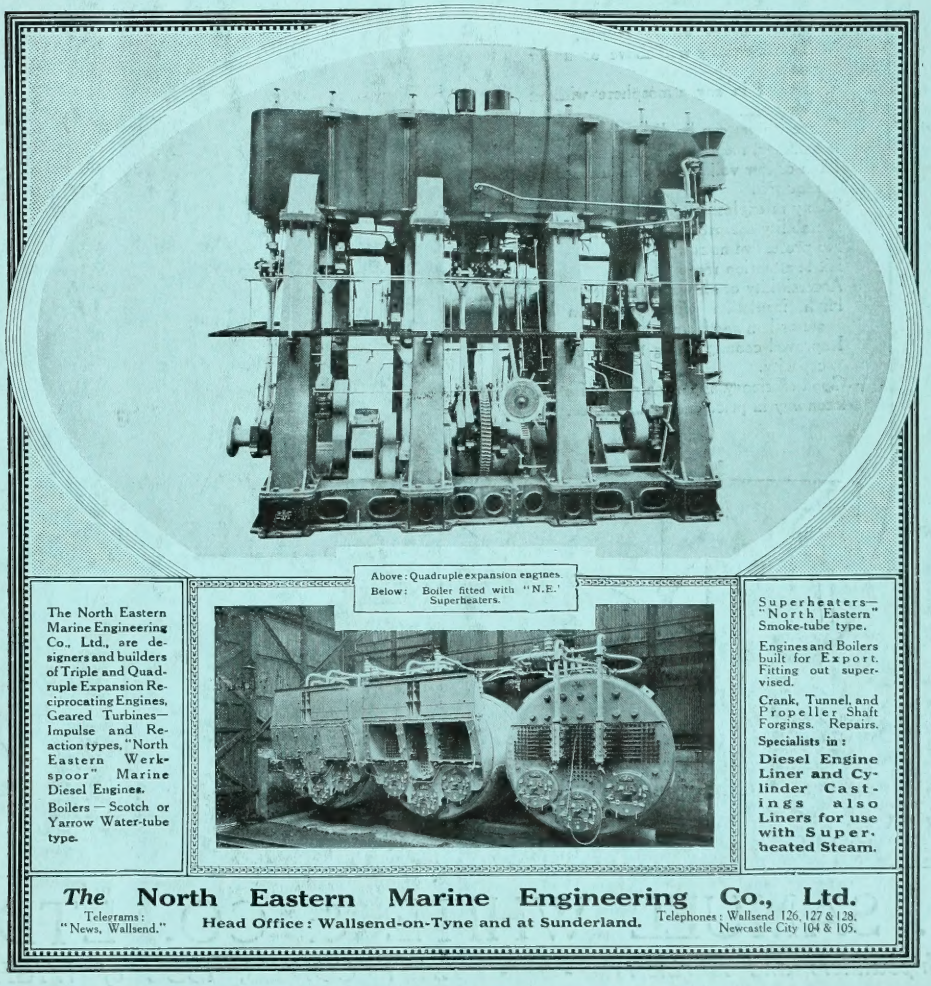

Above: Quadruple expansion engines.
Below: Boiler fitted with "N.E." Superheaters.

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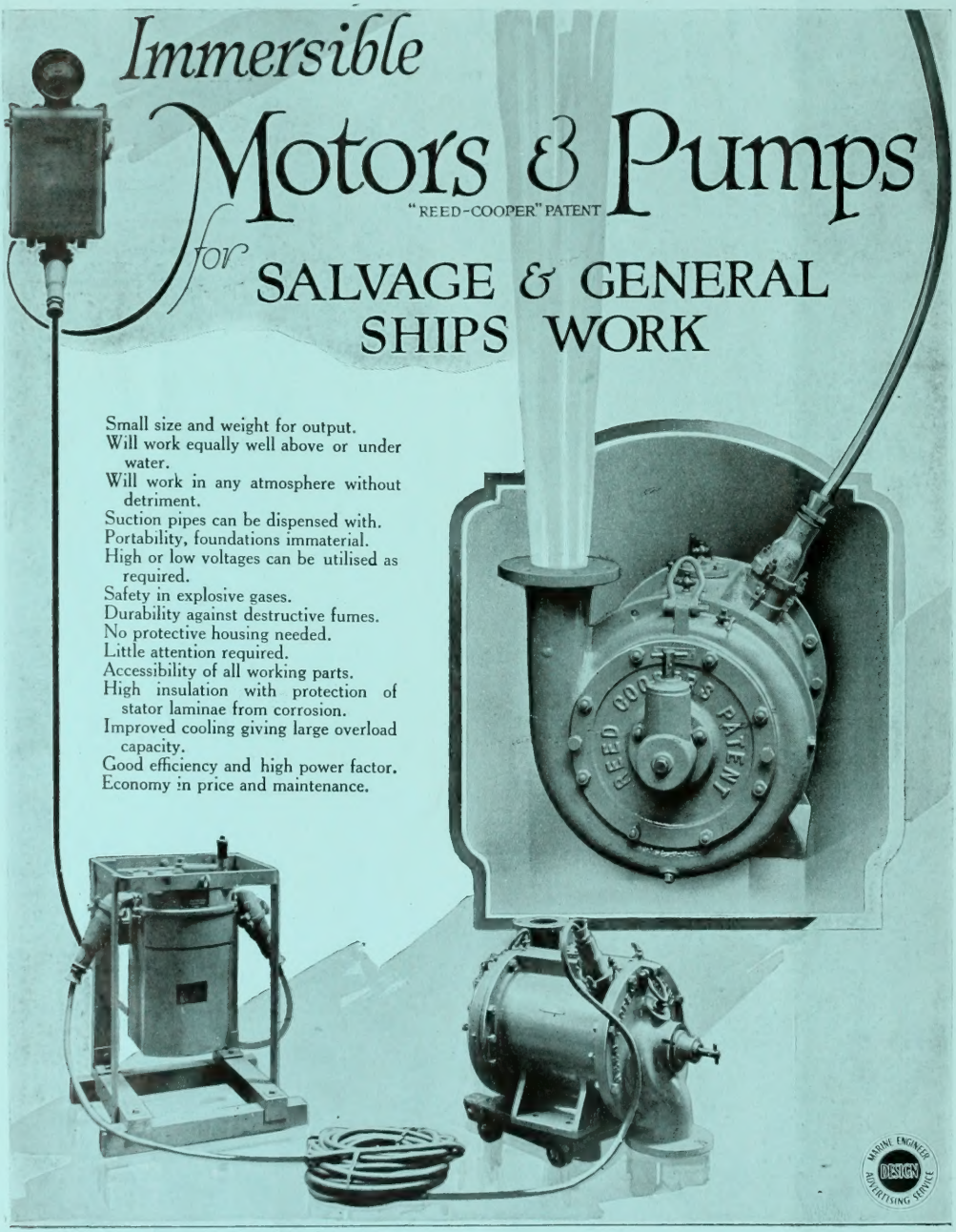

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The Marine Engineer AND NAVAL ARCHITECT.

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

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Mr. Vincent J. O'Connell, Harbour Engineer to the Newry Port and Docks Board, has sent in his resignation to that body.

Captain H. W. Wahlen, Elbe pilot since 1887, died recently at Hamburg, aged 82 years. For many years he was in charge of the trial trips of all war vessels and merchant vessels built by Blohm & Voss, including, only a few weeks ago, the new *Albert Ballin*. He took a prominent part in the work of the Deutscher Seeschiffer Vereine.

Mr. Edward Catmore Chaston, Marine Consulting Engineer, who has died at Newcastle at the age of 64 years, was very well known in shipping circles. He served an apprenticeship in Newcastle and afterwards sailed in Prince Line steamers as Chief Engineer. He settled ashore as a Consulting Engineer a good many years ago and was a member of the firm of Havelock & Chaston, Sandhill, Newcastle. Mr. Chaston was one of five nautical assessors of the Court of Inquiry, presided over by Lord Mersey, which investigated the circumstances of the loss of the White Star liner *Titanic* in 1912.

Mr. Frederick Cresswell Pyman has been appointed Managing Director of William Gray & Co. Ltd., shipbuilders, West Hartlepool, in succession to the late Mr. George Jones. He is a nephew of Sir William Cresswell Gray, Bart., Chairman of the company, and joined the firm in 1911.

Mr. Norris R. Sibley, who was formerly with the London Steam Turbine Company, has now assumed duties as representative of the McClave-Brooks Company, 461, Eighth Avenue, New York.

It is announced that Mr. Arthur C. Besselievre, who is at present with the United States Shipping Board, is to be Professor of Naval Architecture at the Webb Institute of Naval Architecture, Fordham, N.Y.

Mr. Wm. Muirhead, of William Muirhead Ltd., Mount Vernon Iron & Steel Works and formerly Chief Metallurgist with William Beardmore & Co., Parkhead Works, Glasgow, left personal estate in the United Kingdom of the value of £52,976.

Mr. J. Barraja-Frauenfelder, Naval Architect and Marine Engineer, who for the past nine years has had supervision over the high-speed Diesel engine installations for the United States submarines built by the Lake Torpedo Boat Company, at Bridgeport, Conn., has resigned his position as chief engineer of that company. He has been retained by the Sun Shipbuilding & Dry Dock Company, of Chester, Pa., as consulting Diesel engineer, to undertake the development of the Sun-Doxford opposed piston Diesel engines for various commercial purposes.

Geheime Marinebaurat u. Direktor Krell died recently, only two months after his retirement. Though he was only 54 years of age, Herr Krell had a remarkable number of achievements to his credit, and his early death is attributable to prolonged overwork. From 1894 to 1919 he was in various branches of the German Admiralty and was closely associated with the introduction of water-tube boilers and turbines in the German Navy. Much of the equipment at Kiel was due to his initiative and, during the war, he completed plans for a geared-turbine vessel with 300,000 h.p. on four shafts. In 1919 Herr Krell became Director of Construction on the Commission for Reconstruction of the Mercantile Marine. He took a leading part in the assessment of (marine) reparations and, says *Schiffbau*, he rendered important services to German interests in the matter of surrendered vessels, harbour equipment, &c.

Mr. J. H. Narbeth, C.B., C.B.E., M.V.O., retired, under the age limit, last month from the position of Senior Assistant Director of Naval Construction at the Admiralty. Mr. Narbeth was born in 1863 and entered Pembroke Dockyard as a shipwright apprentice in 1877. By means of an Admiralty Scholarship, which he won in 1882, he entered the Royal Naval College at Greenwich and became a student of naval architecture contemporarily with Mr. W. J. Luke, Mr. G. M. Apsey and Engineer Vice-Admiral Sir George Goodwin, K.B.E. In 1885 he went to Portsmouth Dockyard as a third-class Assistant Instructor in the Royal Corps of Naval Constructors, which had only then been formed. Mr. Narbeth was appointed to the Admiralty at the end of 1887, by when he had settled down to the work of design, which became one of his special responsibilities as time progressed. In 1891 he was appointed Secretary of the Admiralty Committee on the sheathing of ships, and three years later became Professional Secretary to the late Sir William White, relinquishing this position in 1897, on being promoted to first-class Assistant Constructor, ultimately becoming Constructor in 1902. About this time Mr. Narbeth, who had been progressing from one stage of design to another, had taken in hand the battleships of the *Formidable* class, and by his work many improvements were effected in the later battleships. Mr. Narbeth rendered innumerable special services during the war, and in 1919 was appointed Assistant Director of Naval Construction.

EDITORIAL.

DANISH INTER-ISLAND SERVICES.

ONE of the most lasting impressions that the visitor to Denmark carries away with him is the slowness and infrequency of some of that country's railway services. This really is in no way indicative of the fact that those responsible for the control of the railways are indifferent to the needs of prospective passengers, but rather of the fact that the country, by reason of its division into islands, is more naturally served by steamship services than by railways. Copenhagen, as the capital and largest town, is the centre from which numbers of steamship lines radiate, making connections with places such as Aarhus, Aalborg, Randers, and Horsens on the West Jutland coast, and with Gothenburg, Christiania, Bergen, and places outside Denmark. The majority of these services are night services—the traveller leaves, say, Copenhagen in the late afternoon or in the evening and reaches his destination early next morning. The vessels engaged on these services remain in port during the following day, and in the majority of cases leave again in the evening. During their stay in port they are fairly consistently employed in embarking and discharging cargo. They are mostly old boats and practically without exception are propelled by reciprocating engines, which latter in many cases are getting well on into middle age, taking steam from Scotch boilers. The following table has been prepared to give some principal features of typical vessels :—

Typical Danish Inter-Island Services.

Service.	Year built.	Tonnages.			I.H.P.	Machinery.
		Gross.	Dwt.	Displ.		
Copenhagen-Aarhus	1912	1627	928	2,571	1,650	Triple exp., 3 boilers.
Copenhagen-Fredrikshavn-Christiania.	1885	1,065	655	1,643	900	Triple exp., 2 boilers.
Copenhagen-Aalborg	1893	1,051	485	1,681	1,200	Recip., 2 boilers.

From this it will be seen that they are all vessels of a strictly intermediate character (as a comparison of deadweights and displacements shows) with gross tonnages round about the one thousand mark propelled by steam reciprocating engines of about 1,000 i.h.p. ; also it will be noticed that in a country in which perhaps more has been done to foster the internal-combustion engine in comparison with its size than anywhere else the steam engine, for this particular service, reigns supreme. Some of the advantages of the former for such services are at once obvious ; as has been seen, the vessels concerned run through the night and tie up all day ; this necessitates banking fires in order to be able to raise steam for the next night's run again, all of which would be obviated with internal-combustion machinery. The fuel question is one of little importance, because Denmark has to import her fuel in any case, while the extra space obtained by the loss of the boiler-room could be devoted to cargo or passenger space. We understand that a vessel is at present on order for the services discussed in this article, which is to be fitted with internal-combustion engines supplied by a well-known Danish firm, and it will be interesting to watch her performance, as a completed vessel, and to note whether she is followed by others similar. It is also known that designs have been prepared for train ferries for Denmark to be propelled by internal-combustion engines, but up to the present we have not heard of their adoption. It is a somewhat curious anomaly, but possibly the explanation is to be found in the fact that very few replacements have had to be made as yet, and when replacements are made we may see the internal-combustion engine tried out with success.

INTERNAL-COMBUSTION TURBINE PROSPECTS.

RADICALLY novel digressions from current practice generally take a considerable time to materialise commercially, and it is by no means the case that those who are initially inclined to condemn them are entirely in the wrong. In matters of engineering, as in most other spheres of life, the attempt to take two steps in one usually proves to be bad policy, and there is a considerable amount of justification on the side of those who prefer to judge the merits of new types of machinery from the point of view of the success which they have attained rather than from that of being potential participants in the efforts directed to that end. Shipbuilders and marine engineers are primarily manufacturers to order, and their establishments are not, except within narrow limits, and should not be, run as experimental plants, and in a very large number of cases it is not that they are unwilling to undertake the investigation of novel ideas, but that it is commercially impossible for them, as trustees of their shareholders' interests, to follow their own inclinations in the matter. Particularly is this the case during a period of very acute trade depression, and for this reason alone it seems somewhat unlikely that much time and money will be expended on the development of the internal-combustion turbine in the near future. The undertaking of experimental work on a full-size scale is an extremely costly matter, mainly because there is no finality about it, and the temptation to go one step further and then another, particularly after partial success has encouraged or temporary failure has tantalised, is very hard indeed to resist. One requires to be very confident that the prize in view is worth the expenditure before embarking upon a heavy outlay.

In the case of the internal-combustion turbine, a great deal of the optimism which has anticipated its appearance has been due to the success of the steam turbine and heavy oil engine, without any regard for the fact that the low efficiency of heat energy conversion in the former can easily be compensated by an extension of the cycle limits, whereas in the latter the conversion is accomplished with very small losses over a much more restricted range of expansion. The difficulty confronting the designer of an internal-combustion turbine lies in applying the cycle of the one type of engine to the mechanism of the other. Hitherto it has proved to be almost insoluble. Quite apart from the mechanical difficulties involved, and which are almost entirely due to temperature, the theoretical cycle on which the internal-combustion turbine must work, and the limits of which can be expressed as $\frac{T_1 - T_2}{T_1}$, cannot, as in the case of steam, be extended beyond that of the piston engine with the usual materials of construction which are available, and in spite of the fact that very great advances have been made during the last decade in the production of heat-resisting steels, it is still in this respect that the chances of a really successful internal-combustion turbine must rest for their ultimate solution, although a considerable measure thereof appears attainable to-day. It is quite certain that no internal-combustion turbine which will compete in fuel economy with the heavy oil engine is likely to be forthcoming for some years.

The actual tentative efforts which have been made at its production since Armengand and Lemale built their first experimental turbine at Paris in 1903 have all failed, with the exception of Holzwartb's designs, for lack of suitable design, and, in the case of more recent attempts, in which the previous theoretical errors have been avoided, the mechanical difficulties due to temperature are such that while they are not

by any means insuperable, they are still sufficient to prove formidable unless the efficiency be sacrificed, or unless mechanical complication be accepted (as is done in the Holzwarth turbine), or until still further progress has been made in metallurgy. How far it is really possible to reconcile these conflicting elements is not easy to define without actual experiment, and at the present time the cost of this appears to be prohibitive, although the incentive to undertake it is very strong. The internal-combustion turbine does not seem at all likely to spring into existence as the result of some lucky invention on the part of a chance designer. The general characteristics of internal-combustion cycles and the principles of heat energy conversion in the turbine form of mechanism are well understood, and it rests very largely with makers of special steels to produce some material which will withstand the requirements of the turbine specialist. In this connection the demand is necessarily for a non-scaling steel which will retain at high temperatures the physical and particularly the elastic properties, which good carbon steel possesses at normal temperatures, and coupled with this must be the quality of maintaining these properties over long periods of working. Much attention is being devoted to this subject at the present time.

THE QUESTION OF BOILER WATER CIRCULATION.

CURRENT practice in the equipment of merchant ships points to the fact that in this country, at least, the cylindrical marine boiler, or the Scotch boiler, as it is familiarly called, still meets with general favour in the eyes of shipowners. It is, of course, very generally recognised that the water-tube boiler is far more economical as a steam raiser, particularly when oil fuel is employed, and that, weight for weight, it is capable of developing a much greater quantity of steam than the older fire-tube type. But for general reliability, ease of upkeep and repair, and also because comparatively unskilled labour is capable of operating the cylindrical boiler, the type has not yet been displaced. The chief reason why the water-tube boiler possesses a greater capacity for raising steam than the cylindrical boiler is because the arrangement of tubes and drums leads to a far better circulation of the water, so that the cooler water is continually presented to the heating surface. This, unfortunately, is not the case in the cylindrical marine boiler, and not only does this result in a far slower rate of steaming, but it leads also to the setting up of strains in various parts of the structure due to differences of temperature, these strains causing distortion of the plates, leaky seams, cracked plates and general deterioration of the material.

It is well known by marine engineers who have had actual sea-going experience that there is a volume of water which lies dead under the middle furnace, and since water is a very bad conductor of heat, it may take a considerable time before a uniform temperature is attained throughout the boiler. In any case, on starting up the boiler from cold, even if steam is raised very gradually, it is quite general to have the steam at blow-off pressure, *i.e.*, the water at the top of the boiler at a high temperature while the water at the bottom of the furnace is quite cold, and even after as much as two days' steaming it has been found that the bottom of the boiler is cold enough to bear the hand on. Thus, with a working pressure, 210 lb. per square inch, the temperature of the water at the top of the boiler is about 395° Fahr., so that if the temperature of the water at the bottom be 75° Fahr., there is a difference of temperature of 320° Fahr.; this, in a boiler 15 ft. long, means a difference of length between the top and the bottom of about 0·38 in. Obviously, this is quite enough distortion to cause a starting of the joints no matter how well they may have been made. The figures taken may represent somewhat an extreme case, but it is apparent that the considerable differences of temperature which do exist may cause very serious strains to be set up.

That marine engineers have been alive to the seriousness of this problem is shown by the fact that there have been placed upon the market many types of water circulators, all of which claim to remedy the evil effects caused by differences of temperature in the same structure and also to increase the steaming capabilities of the boiler by setting up a circulatory system which continually brings the cold feed-water into contact with the heating surface. That many of these devices are successful we do not deny; we ourselves have had experience at sea under actual running conditions with boilers fitted both with and without circulating devices and can testify to the beneficial effects which are obtained by their use and also to the increased steaming capabilities of the boiler. But the fact remains that very many superintendent engineers are unwilling to use fittings of this nature, possibly because they know that the men on watch often neglect to operate these devices and they gradually get into such a state that they cannot be used when it is required to do so.

FROM THE "MARINE ENGINEER," SEPT. 1879.

Mechanical Engineers' Visit.—The members of the Mechanical Engineers, during their late meeting at Glasgow, visited the shipbuilding and engineering works of W. Denny & Bros., Dumbarton, where a large amount of work is being performed of the most interesting and diversified character. Indeed, at a time when the shipbuilding trade throughout the country is at a lower ebb than it has been for many years, when numbers of yards on the Clyde are practically closed, and when many on the North-East Coast are doing but little, it is surprising to see how busy the little town of Dumbarton is kept going . . . They have at the present moment 10 ships in hand, and of these no less than nine are of steel.

Extension to London Docks.—In spite of the long-continued depression in the shipping trade, we note that a new dock has just been opened at Blackwall as an extension to the East and West India Docks. Its area is about six acres. At ordinary spring tides there are 31 ft. of water above the stone sills against which the lower edge of the gates fit, and the largest ocean-going steamers can thus enter the basin for some time before and after high water. This, it is said, is a greater depth by some 4 ft. than is to be found in any other dock in the Thames.

Watertight Doors.—In another part of this issue we have given illustrated details of a very simple and efficient sliding door for watertight bulkheads. We think this subject is an all-important one to those who trust their lives to our present iron ships. A leak is easily caused, and is almost impossible to promptly repair on an iron hull, so that the vessel must depend for safety, under leakage, almost entirely on its watertight compartments. When we hear, as is quoted in the article above referred to, that a seagoing engineer, essaying to shut one of the usual screwed watertight doors, found it took half-an-hour to effect the operation, it is forced upon our conviction that such an arrangement would be perfectly useless in time of need.

Life-Saving Apparatus.—On Saturday morning a trial of a cleverly-constructed life-belt, invented by Mr. C. O. Weeks, Board of Trade Surveyor at Southampton, was made in the Southampton Docks in the presence of a large number of gentlemen connected with the shipping interests. The belt consists of a small airtight copper vessel, which is so influenced by a concealed brass spring as to cause it to encircle the body, and by an ingenious and simple contrivance it becomes attached firmly, yet comfortably, to the person.

Status of Naval Engineers.—"To the Editor of the *Marine Engineer*.—Sir, Seeing that you are devoting attention to the position of marine engineering, I venture to hope you will do your best to ventilate some of the grievances of the engineers of Her Majesty's service. The subject of pay which you have been ventilating is, of course, all-important; but, at the same time, social position and recognition amongst our fellow officers is as sore a subject with ourselves of the Navy . . . ."

Navigation.—The trial trip of the new screw steamer *Navigation*, which has been built to the order of Dixon & Harris, of London, by Palmers' Shipbuilding & Iron Company Ltd., Jarrow, took place on July 30. The dimensions of the vessel are:—Length, 250 ft.; breadth, 34 ft.; depth, 22 ft.; carrying capacity, 2,200 tons. The engines (also built by Palmers' Company) are of 160-h.p. nominal, and work up to 850 h.p. The diameters of the cylinders are 30 in. and 60 in. respectively, the stroke of the piston being 39 in., and the number of revolutions 86 per minute, whilst the working pressure upon the boilers is 85 lb. to the square inch.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

The Engineer's Pocket Technical Dictionary. (French-English.) By Mark Lvoff. London: E. & F. N. Spon Ltd., 37, Haymarket, S.W.1. 4½ in.×6¾ in.×½ in. 150 pp. Price 3s. 6d. net.

A great bar to international engineering progress is the question of differences of language, and for this reason much of the most valuable information obtainable from the foreign technical press is lost. Anything which helps to bridge this difficulty therefore is welcome. The book we have under review contains a number of important engineering and technical words not to be found in other dictionaries. The author has been enabled to keep the size of the book down by omitting many words which, while included in other technical dictionaries, are seldom or never used, and a good many others the meanings of which by their similarity to the English word are sufficiently obvious. The dictionary, while being general in its scope, is particularly concerned with mechanical and electrical engineering, the iron and steel industry, aeronautics, the motor car and cycle industry, and legal and commercial words used in contracts and specifications.

Oil Fuel Burning at Sea and on Land. By James Sandford Gander, M.I.Mar.E. Glasgow: James Munro & Co. Ltd., 35-37, Washington Street. 6½ in.×9¼ in.×1 in. 356 pp.

The author sets out to deal with a vast subject in this book, and the manner in which he does so leaves very little to be desired. In the first place, we feel that the subject is one of extreme importance for all marine engineers and especially at the present time when oil is waging a battle with coal for supremacy; and in the second place, we feel that we are reading the mature result of many years of experience. The historical side of the question is dealt with first, and this is followed by sections dealing with the origin of mineral oil, the geology and chemistry of fuel oil and methods of drilling for oil. Marine engineers will find of particular interest a section describing a supposed voyage on oil fuel in which the ship arrives in port and is converted from coal to oil burning. A small section is devoted to storage tanks and a useful typical "midship" section through a tank is appended; there is also a list, complete to the time of going to press, of the principal oil fuel bunkering ports at home and abroad. The book is not arranged in numbered chapters in stereotyped fashion, but in separate sections, and it is proposed to publish an annual revision in order to bring the work up to date.

La reception des combustibles liquides (Fuel Oils et Gas Oils). By Camille Denier, director of "La Compagnie Occidentale des Produits du Pétrole." Paris: Bibliothèque du Bureau Veritas, 40, Rue de Seine. 5 in.×8½ in.× ⅜ in. 116 pp. 44 figures and 2 folding plates. Price 12 francs net.

This little book describes in as concise a manner as possible the different methods of handling and analysing fuel oils and gas oils; each operation touched upon is described with considerable care for detail, and the descriptions show that the author, besides having considerable theoretical knowledge, is thoroughly well versed in the practical side of the question. The book is divided into three sections, the first of which deals with laboratory experiments. The second section is devoted to such experiments as can be carried out in large works or upon oil-burning steamers. The third describes experiments which may be carried out anywhere where proper apparatus is not at hand. There is also an appendix containing tables of viscosity, &c.

The Model Engineer Series, Nos. 48, 49 and 50. London: Percival Marshall & Co., 66, Farringdon St., E.C.4. 4⅞ in.×7⅜ in.×¼ in. Price 9d. net.

No. 48, *Gear Wheels Simply Explained*, by Alfred W. Marshall, M.I.Mech.E. (63 pp. and 60 illus.), has been written to enable the reader to understand the principles which underlie the somewhat complicated subject of gears and gearing; it is lucid and well written.

No. 49, *Screw Cutting Simply Explained*, by George Gentry (63 pp. and 21 illus.), assumes initially that the general construction and working of a screw-cutting lathe are understood, and goes on to deal with the subject in a series of paragraphs more or less in sequence; it uses a method of notation "which has been found to make the matter clearer and more easily digested than the method usually employed in text books."

No. 50, *Clock Repairing and Adjusting*, by W. L. Randell (68 pp. and 37 illus.), is written for "those who have had no experience of clockwork, as an introduction to a branch of mechanics which becomes more attractive the more it is studied."

Travaux Maritimes, La Mer and Les Côtes. By G. de Joly. Paris: Grandes Encyclopédies Industrielles J. B. Bailliere. 6¾ in. × 9 in. × 1 in. 472 pp. Price 45 fr.

This book, written originally by the late M. Georges de Joly, Inspecteur des Ponts et Chaussées, is edited by M. Charles Laroche, Professor in the national school "des Ponts et Chaussées." It covers a vast field in matters connected with coastal works, &c., and contains altogether 12 chapters dealing with such subjects as the action of sea water upon materials of construction, winds, tides, currents, coast erosion, coast defence, ships, navigation, lighthouses and maritime signals. This last subject is exceptionally well treated in Chapter XII, which is divided into three sections, the first of which deals with day signals, the second with night signals, and the third with aerial signals. A criticism which we feel inclined to make of this book is the fact that it attempts too much, since almost any one of the subjects mentioned above would form a volume of its own. It has the advantage, however, which is an inherent feature of all "multum in parvo" books, that it enables the man who wishes to obtain a rough outline of a subject to do so in the minimum of time. Two more volumes of this same work are forthcoming, one of which will deal with the exterior works and entrances to ports and the other with the interior works of ports.

TRADE PUBLICATIONS.

The Economic Utilisation of Heat is the title of a profusely illustrated catalogue issued by Royles Ltd., Engineers, Irlam, near Manchester.

Brookhirst Switchgear Ltd., Chester, send us their latest leaflet, No. 122, entitled "Motor Starting Panels for Marine Service." The leaflet is well illustrated and very informative.

The English Electric Company, Queen's House, Kingsway, London, W.C.2, are the authors of a booklet entitled "List of Rotary Converter Installations."

Michell Bearings Ltd., 3 Central Buildings, Westminster, S.W.1, describe in a small leaflet their oil deflectors for the prevention of the escape of oil from the ends of bearings. They have also issued a leaflet giving prices and dimensions of their standard types "S" and "E" and collars.

STEAM RAISING AND THE PREPARATION OF STEAM RECIPROCATING ENGINES FOR SEA.

Boiler Lighting-up Arrangements—Oil Fuel—Main Engines—Thrust Block.

The raising of steam in a marine type cylindrical boiler calls for the exercising of care and judgment if the undertaking is to be performed satisfactorily and economically. With a view to promoting the most efficient natural circulation of water, for instance, it is often stated that one of the wing furnaces should be lighted first, although the practice of firing up a centre furnace first would appear to have equally good reasons to recommend it if the question be considered closely.

Lighting-up a Boiler.

Broadly speaking, both methods are equally good in practice, although in some cases one method shows a marked superiority over the other procedure, due possibly to the peculiar baffling of some boilers. Some keen engineers pride themselves on the rapidity with which they can raise steam, but nothing is more extravagant and detrimental to a boiler than this short-sighted policy. The use of a hydrokineter as an aid to the natural circulation of a large boiler during steam raising is the safest and most satisfactory method of accelerating steam production. By its use the water is rapidly and efficiently circulated and excessive temperature stressing avoided in the boiler. The simple calculation necessary to show the very considerable strain imposed on a cylindrical boiler in reaching normal working pressure and temperature show very clearly the folly of forcing steam raising. When a hydrokineter is not fitted to a boiler, donkey pump circulating connections should be installed and this latter auxiliary brought into service to assist circulation. In vessels having oil-fired boilers steam-raising methods are mostly unsatisfactory, dangerous and expensive owing to there being, it is assumed, no steam heating of the fuel oil available.* Sometimes a small coal or wood fire is started in one of the furnaces and fuel oil allowed to play on the burning wood after a while; this, however, is an expensive proceeding at best. Another method often used is that of passing the oil by means of a hand pump through an auxiliary heater and from there to the furnace burners. This method again is expensive and troublesome, for paraffin burners are necessary to heat the fuel oil and five or six men are employed for a considerable time during the operations keeping up the pressure with a hand pump. The writer remembers seeing a suggestion that arrangements should be made on an oil-burning steamer for connecting the fuel oil pump and oil heater to some outside source of steam, such as a tug, in order to have a safe and sure means of raising steam without trouble. Such a course has much to commend it but would prove rather expensive. An alternative arrangement proposed is the installation of a small paraffin-fired water-tube boiler in the ship, of sufficient capacity to supply steam to the fuel oil heating coils, fuel pump, its own feed pump, and, in vessels fitted with smokebox superheaters, additional steam to drive the fan engine. This scheme is perhaps the best and, in the end, the most economical method of ensuring trouble-free generation of steam in an oil-fired boiler despite the outlay on the additional plant.

Oil Fuel Arrangements.

The pressure system is the one most generally used on shipboard as it makes for the highest boiler efficiency and uses the least amount of steam, which steam is led back to the boiler as fresh feed. The oil should be efficiently heated before passing to the fuel pumps, the temperature to which it is raised depending on the specific gravity; the heavier grades require a higher temperature for efficient atomisation than the light oils. With the different grades of fuel oil generally used one may place the temperature range at around 240° to 120° Fahr., according to the nature of the oil. Efficient steam heating coils are also advantageous in the storage tanks when heavy oil is used, these being particularly valuable in cold weather and when a tank is almost empty; about 2 sq. ft. of heating surface per ton of oil carried will be found ample for the heaviest fuel oils.

A high pressure and temperature facilitates atomisation of fuel oil, as does a plentiful hot air supply, although both these points need very careful watching for the best results. Too high a temperature accelerates carbonisation in the heaters and often results in irregular combustion through the water present in the oil vaporising. Too much air affects the fuel consumption to a greater degree than does too little (a point not always appreciated), regulation being desirable until a faint haze shows at the funnel top or until 12 per cent. of CO_2 is indicated on the recorder.

Naturally, with natural draught any variation in atmospheric pressure will call for a readjustment of the boiler air supply, although with forced draught, once a good setting is arrived at it should be left alone, when it will be found that tubes, coils, &c., keep very clean.

Main Engines.

Turning now to the engines, we will consider the usual triple-expansion unit driving its own bilge, feed and air pumps, and having an independent circulator. This latter auxiliary should first be started up and its correct discharging ascertained. Having noted that the main regulator valve is shut and all cylinder drains open, ease the main boiler stop valve just off its seat and allow a small quantity of steam to pass into the main steam range, the pipe drains being open. Until these latter blow steam a look should be taken around the engine to ensure that everything is clear and that the turning gear is "out," and so on. In a few moments the regulating valve should be opened slightly and the steam pipe drains closed. The pressure gauge on the high-pressure receiver gives a good indication of the amount of opening given to the regulator valve, provided the stop valve is only opened a small amount, and should be consulted each time the regulator valve is opened during the initial warming through of the engine. After a while the regulator valve should be opened further and the intermediate pressure and low pressure starting steam valves opened somewhat, care being taken that only a pressure of 2 or 3 lb. per sq. in. is registered on the receiver gauges. While the engine is thus warming through the links should be in either the full ahead or full astern position, obviously. At this stage the eccentric troughs should be examined and filled up with fresh water, all oil boxes filled and syphon wicks examined and the guides water service tried.

As the temperature of the engine rises, steam should be gradually opened to the reversing engine and the amount of condensate passed to the condenser ascertained, otherwise it will be lost by way of the air pump overflow if allowed to accumulate. Usually the condenser is fitted with a donkey pump suction, and this should be connected up and the condenser pumped out about every hour during the warming-through

* See, however, *The Marine Engineer and Naval Architect*, July, 1923, p. 250.

stage, which may occupy four hours or more, depending on the size of engine and the quantity of heating steam available.

Thrust Block.

Attention should now be turned to the thrust block and all clearances checked if deemed desirable (we will assume a multi-collar thrust). Fresh water should be added to just below the level of the collars and then clean oil poured in so that the collars will dip about 1 in. into the oil when running. Should the trough contain too much water it will be found that the revolving collars will very soon mix the water and oil into a thick emulsion which will cause serious overheating of the thrust and probably a consequent delay while cleaning out is performed. Such inattention—or perhaps over-attention—is really more disastrous than running a thrust block with too low a water level. The Michell thrust generally requires no attention and it functions most admirably without anything beyond correct lubrication with suitable oil. The importance of ensuring the absence of foreign matter in the oil need not be enlarged on, as a breaking down of the oil film is a more serious matter than when dealing with a multi-collared thrust, in view of the high thrust pressures prevailing—300 to 400 lb. per sq. in. as against 50 lb. per sq. in. in the older pattern. Should a journal bearing or thrust pad be scored or in any way faulty, scraping, &c., should not be attempted, but the spare fitted. It is a good plan to dose a new " brass " with castor oil before fitting, as this oil puts a hard wear-resisting skin on the white metal. (Such a precaution would be superfluous when fitting a new thrust pad, of course, as the unique Michell " wedge " principle of lubrication never allows metallic contact to take place between the relatively moving surfaces.)

By the time the thrust block has been examined the engine will be about ready for a few turns, so the boiler stop valve should be opened further, the throttle valve opened a little, and the reversing engine set slowly in motion. The main engine can be allowed to swing up and down for a few moments so as to permit of a thorough circulation of steam before actually starting up.

After stopping the reversing engine (with the links in the ahead position) the engine should be run slowly ahead for a while and then gently astern.

Having closed all but the low-pressure drains the engines may be reported to the bridge to be ready, it being ascertained that the valve gear is in " full link " for manœuvring, all syphons open, and the necessary pumps and water service ready for orders to start.

LETTERS TO THE EDITOR.

MARINE BOILER PLANT EFFICIENCY.

TO THE EDITOR OF THE MARINE ENGINEER AND NAVAL ARCHITECT.

The following points appear important, in reference to Mr. Brownlie's article, " Marine Boiler Plant Efficiency," which appeared in your July issue. I have carefully studied and received great benefit from Mr. Brownlie's publications on economical power production, and, therefore, make no apology for adding the following to his article. It is true that, as far as the *boiler* is concerned, the land and marine type do not differ greatly in their performances, but in making an estimate of the probable saving I think the following should be considered : (1) The marine boiler is generally well lagged, and this cannot be said for the average land boiler found about collieries and chemical works. (2) The chief loss in marine boilers is in that they are overdriven, particularly with forced draught. The land boiler has trouble with leaky brick settings, which are eliminated in the marine boiler. (3) The firemen afloat and ashore are different and their conditions of labour are different. The land firemen can be discharged at the end of the week, while this hold on the men is lost at sea, since the firemen, in nearly every case, leave the ship at the end of the voyage. The conditions in any stokehold are unpleasant with coal-fired boilers, but a ship's stokehold in the tropics is horrible ; hence the efficiency of the men is reduced.

On the whole, the condition of the marine plant tends to higher efficiencies, in that :—the steam pipe lines are shorter, and the plant is more compact, particularly when compared to collieries and chemical works, which, if I remember correctly, form a large percentage of Mr. Brownlie's average on land. The main boilers on a marine plant are worked at full power all the time and not shut down at night, nor eased up for meals. In port a small donkey boiler is used. The marine boiler is cleaned more frequently and looked after with greater care. Generally, I believe the feed water is in a better condition. In a large number of ships, of course, we use an evaporator, and this would tend to reduce the thermal efficiency of the plant ; on the other hand, however, better feed water is obtained, and often an actual saving in money effected by the increased cargo space available.

No doubt 10 per cent. gain would be obtained in a good many cases, especially in ships having independent feed, air and circulating pumps. Yet the average saving would be reduced by the fact that a large number of ships have their main feed pumps, air and circulating pumps driven off the main engines. The feed is delivered at about 160–170° F. This is unalterable, because I do not believe at the present time any owner of this class of ship would go to the expense of altering existing arrangements.

I have carried out a good many of the tests required for the formation of a heat balance sheet at sea, and have found that provided the instruments are carefully chosen or adapted for marine work, no very great difficulties are met with, except the measurement of coal at frequent intervals, and using a chemical balance in bad weather—an obvious precaution eliminates this.

DOVER. ERIC PRINCE.

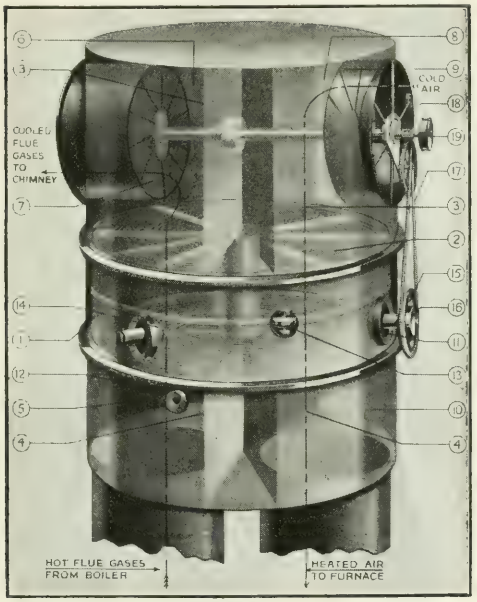
THE SHIPPING EXHIBITION.

The following programme of meetings of the Institute of Marine Engineers at The Shipping and Engineering Exhibition, Olympia, London, W., has been drawn up :—Thursday, September 6—1 p.m., Luncheon at the Exhibition, where the President and Council are looking forward to meeting all members home from abroad, by invitation of the Organisers, F. W. Bridges & Son. 3.45 p.m. " A Note upon Cast Iron for Marine Engine Castings from the Metallurgical and Engineering Points of View," by H. J. Young, F.I.C., and E.Wood, B.Sc. 5 p.m. Tea, to which all members are invited. 7 p.m. Paper on " Life-Saving Appliances on Large Passenger Steamers," by E. W. Blocksidge. Tuesday, September 11.—7 p.m. " With Shackleton in the Antarctic, 1914-1917," by Engr. Lieut. Rickinson, R.N. Lantern Views. Ladies' Night. Including invitation to tea at 5 p.m. Tuesday, September 18.—7 p.m. " Super-Heating," by John Neill, B.Sc. Those who wish to receive entrance cards to the Exhibition on the dates given above should send application as early as convenient to the institute, including acceptance of invitation to tea at 5.

AIR HEATING BY WASTE GASES.

The Uses and Operation of the Howden-Ljungström Air Preheater.

In the general desire, in the marine engineering world, for the reduction of the cost of steam power, the attention of inventors has been directed hitherto almost exclusively to the improvement of the performance of the prime mover, and remarkable progress has been made in the economical use of steam, while the really fundamental question, that of the economical production of steam, has attracted comparatively little attention. The importance of the recovery of heat from the waste gases, however, was early recognised by the firm of



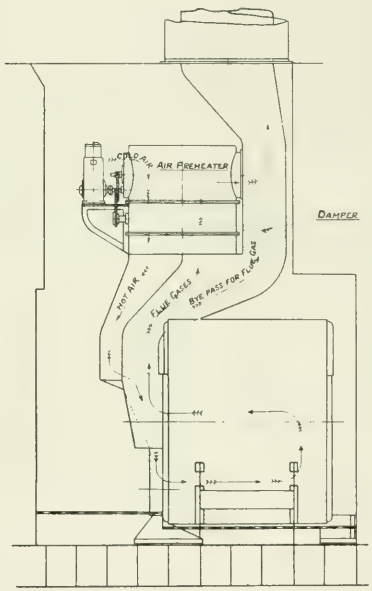
1. Rotor.
2. Heating elements.
3. Upper partition wall.
4. Lower partition wall.
5. Lower flue gas chamber.
6. Upper flue gas chamber.
7. Flue gas fan.
8. Upper air chamber.
9. Air fan.
10. Lower air chamber.
11. Driving roller.
12. Soot blowing device.
13. Guide roller.
14. Carrying roller.
15. Sprocket wheel.
16. Clutch.
17. Chain.
18. Speed reducing gears.
19. Pulley.

Diagrammatic View of the Howden-Ljungström Air Preheater.

James Howden & Co. Ltd., and a further important innovation in this connection has been placed on the market recently by the firm of Ljungström, of Stockholm. Ljungström's, very early in their experiments, realised that maximum economy could be obtained only by utilising the heat contained in the waste gases to an extent much greater than had been common before, and it was with this object in view that the Ljungström air preheater was invented. Trials were made and the apparatus was proved to be satisfactory practically from the beginning. It was seen that the principle lent itself readily to the design of preheaters for many types of furnaces, especially for those of marine steam boilers of all kinds.

The principle involved is exceedingly simple and effective. Briefly described, it is somewhat as follows :—A large transmission surface is assembled in a rotating part in such a way that the elements are alternately traversed by the waste gases from the boiler and the cold air to be used for combustion. The gases give up their heat to the elements, and as these move round into the current of cold air, the heat previously given up by the gases is taken up by the air. The process, it should be noted, is continuous.

In actual construction the elements consist of thin plates of metal placed close together and corrugated in order to obtain a very large surface. They are fixed in the rotor, which is of disc form, in such a way that the passages for the gas and the air between the plates are parallel with the axis of rotation. The rotor is supported upon rollers carried in ball bearings fixed in a stationary cylindrical casing, so that the power required to drive the rotor is only a fraction of a horse-power.



The Howden-Ljungström Air Preheater applied to Single-ended Marine Boiler.

In the sections above and below the rotor the casing is provided with inlets and outlets in such a way that the gases and the air traverse the rotor in opposite directions, and a counter-current effect is produced. The gases and the air are separated from each other by diametral partitions in the upper and lower sections. In the upper section two fans are provided, one to force the cold air through the elements which are at the moment travelling through the air side of the heater, and the other to suck the gases through the elements on the gas side. The two fans are mounted on one shaft passing through the upper partition. The shaft can be driven by an electric motor or in any convenient way, the rotor, which in all sizes revolves at 6 r.p.m., being driven by suitable gearing.

By this simple mechanism it is possible to reduce the temperature of the waste gases leaving the boiler to a point hitherto

regarded as impracticable. From 70 to 75 per cent., according to circumstances, of the heat contained in the waste gases, can be recovered, a result impossible with heaters of the ordinary type without a very large and costly extension of the surface and a great increase in weight and in space occupied.

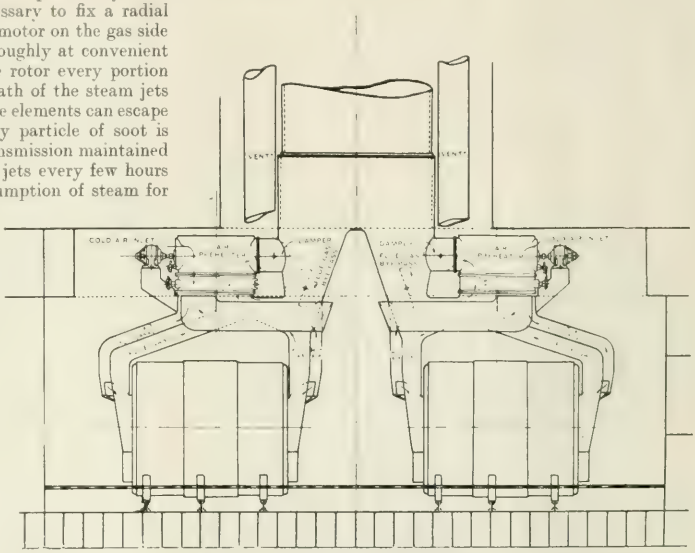
An important feature of the heater is the ease with which the surfaces of the elements can be kept in practically their original clean condition. It is only necessary to fix a radial steam pipe, fitted with nozzles, below the motor on the gas side to enable the surfaces to be cleaned thoroughly at convenient intervals. During each revolution of the rotor every portion of the elements must pass through the path of the steam jets below them. No part of the surface of the elements can escape the scouring action of the steam. Every particle of soot is blown away, and the efficiency of heat transmission maintained constant. It is necessary to operate the jets every few hours for about 15 seconds only, and the consumption of steam for this purpose is, therefore, negligible.

The firm has secured, we understand, the exclusive rights for the application of this apparatus to marine work throughout the world, and has obtained a licence for land installation also. The Howden-Ljungström preheater itself has been thoroughly standardised in all sizes, but special consideration will be necessary in some cases.

We append herewith some interesting test figures which were obtained from a cylindrical type marine boiler fitted with one of the preheaters described above. The boiler had two furnaces, each having a diameter of 3178 in. and a total heating surface with coal of 910 sq. ft.; the corresponding heating surface with oil, the bars being removed. Retarders were in position in the tubes. The results are as follows :—

Conditions.	Coal-burning.		Oil-burning.	
Date	31.1.23	14.2.23	5.3.23	6.3.23
Duration, hours	5	4	4	4
Steam pressure, lbs. per sq. in.	164	167	161	161
Average feed temperature, deg. F.	180	165	179	172
Class of fuel	Scotch coal	Scotch coal	Mexican oil	Mexican oil
Calorific value of fuel, B.T.U.	13,055	12,300	17,574	17,574
Fuel burned per hour, lbs.	540	636	453	495
Equivalent evaporation per lb. Fuel, lbs.	11·12	10·19	15·97	15·76
Equivalent evaporation, sq. ft. Heating surface, lbs.	6·6	7·12	6·99	7·54
Temperature of flue gases entering air preheater, deg. F.	538	561	537	554
Exit temperature flue gases, deg. F.	217	231	195	215
Temperature air entering fan, deg. F.	76	66	77	77
Temperature of air leaving preheater, deg. F.	419	427	426	427
Temperature of air entering furnaces, deg. F.	405	415	398	409
Air pressure in reservoir around furnaces, inches W.G.	0·35	0·34	0·31	0·32
Air pressure at furnace door, inches W.G.	0·06	0·02	0·16	0·15
Air pressure at ashpit door, inches W.G.	0·30	0·30	0·24	0·23
CO_2 in flue gases, per cent.	9·5	9·0	11·1	11·0
Thermal efficiency of boiler	84·36	85·49	87·6	87·13

The results of these trials, which were very exhaustive, show that the funnel losses need not exceed 6 per cent., the net efficiency obtained at the same time being in the neighbourhood of 90 per cent. This performance, although obtained under test conditions, indicates that it is possible to effect fuel savings of from 12 per cent. to 23 per cent. according to circumstances, by extracting heat from the waste gases.



Method of application of the Air Preheater to 15,000 i.h.p. Mail Steamer with double-ended boilers.

It is certain that in some cases the boiler efficiencies obtained in actual practice at sea are low, but with even the best supervision there still remains great scope for the improvement of the efficiency of the boiler plant itself in absorbing the heat generated in the furnaces by either solid or liquid fuel. The cylindrical marine boiler, which has been applied to many millions of horse-power, has shown itself capable of giving excellent results. From furnace to smoke-box it is hermetically sealed and its radiation losses are low, but the gases enter the smokebox at comparatively high temperatures. Even with careful attention the efficiency may be as low as 70 per cent., and it is possible, under less favourable conditions, for as much as 35 per cent. of the calorific value of the fuel to be allowed to escape to the funnel. This question of the recovery of heat from the waste gases is, therefore, of fundamental interest.

SMITH'S OIL-BURNING SYSTEM.—The business of the manufacture and supply of the Smith's patent oil-burning installations will in future be in the hands of Swinney Bros. Ltd., of The Wansbeck Ironworks, Morpeth, Smith's Dock Co. Ltd. having granted this firm the licence as sole authorised manufacturers under the patents held by them. The change is in reality a very slight one, for, we understand, Swinney Bros. have done most of the actual manufacture in the past for Smith's Dock Co. There will also be absolute continuity of management and technique, for Mr. H. A. Thompson, who for ten years has been manager of this department of their business for Smith's, and to whose ability its success and development is largely due, is joining Swinney Bros. as director and general manager.

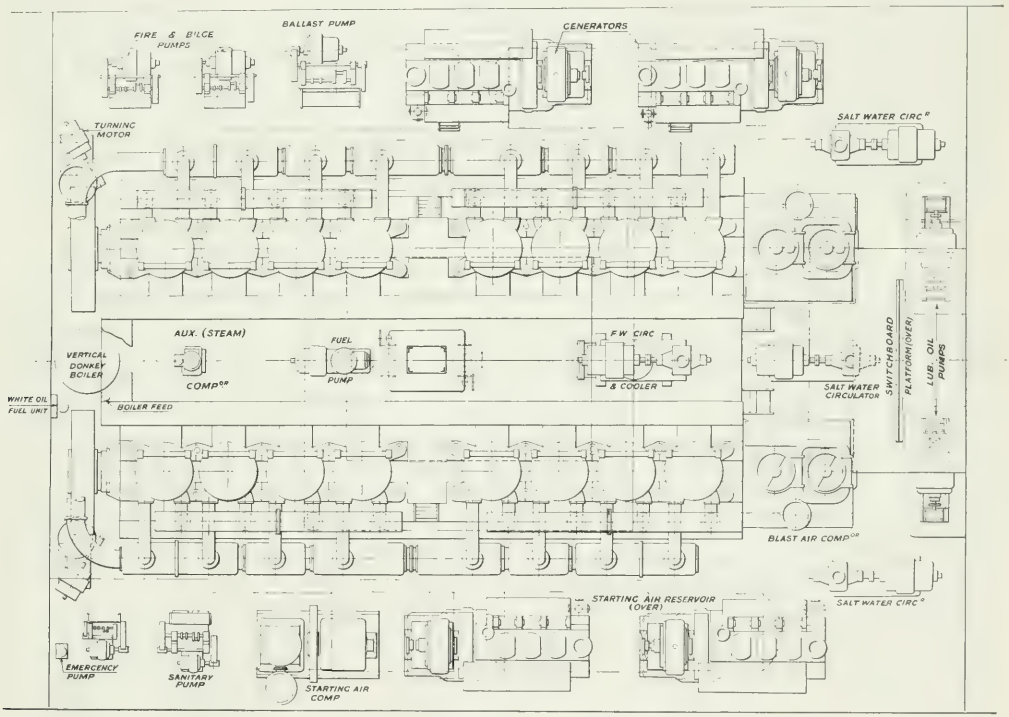
MODERN MACHINERY SPACES—VI.

The Motor Cargo Vessel "Tantalus," Built by the Caledon Shipbuilding & Engineering Co. Ltd., for Alfred Holt & Co. Ltd., Liverpool, and engined with Burmeister & Wain engines, constructed at Copenhagen and installed at Dundee.

We reproduce in this article some of the principal features of the machinery space of the cargo liner *Tantalus*, which was built by the Caledon Shipbuilding & Engineering Co., Dundee, engined by Burmeister & Wain, Ltd., Copenhagen, and completed towards the end of June of this year. She is intended for the Far Eastern service of her owners, and has the following dimensions and characteristics :—

Length overall	477 ft.
,, b.p.	452 ft.
Beam	58 ft.
Depth	35 ft. 3 in.
Draught (load)	28 ft.
Deadweight capacity (fuel excluded)	10,000 tons

about 3,000 I.H.P. ; the cylinder diameter is 740 mm., and the stroke of 1,150 mm. ; the engines run normally at 115 r.p.m. ; and the ship has a service speed of about 13½ knots. A general outlay of the machinery space will be found below, and from this it will be seen that there are two blast air compressers arranged at the forward end of each engine. These are driven off an extension to the crankshaft, and we illustrate the tops of the port pair on page 326. The control gear and manœuvring position is illustrated on page 328 ; the setting of the valve gear for ahead or astern running of the engines is carried out by means of a single lever. It will also be observed that there are two other levers shown in the photograph ; each



The Machinery Space Outlay of the Motor Ship "Tantalus."

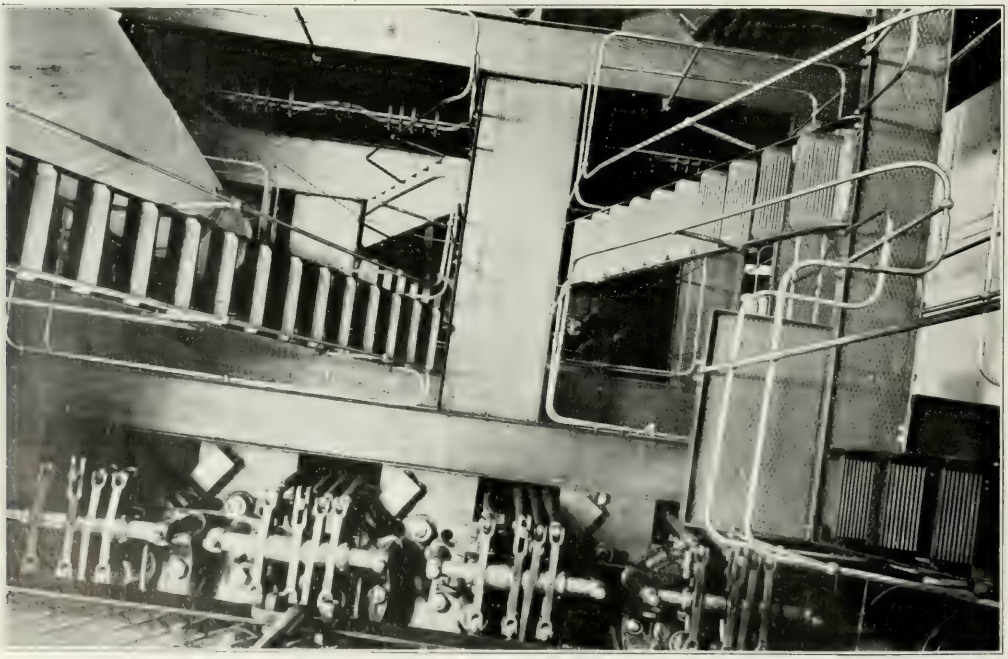
All necessary arrangements have been made in the vessel with a view to her carrying pilgrims, and she carries a Board of Trade passenger certificate.

Main Propelling Machinery.

The main propelling machinery consists of two sets of Burmeister and Wain eight-cylinder engines, each developing

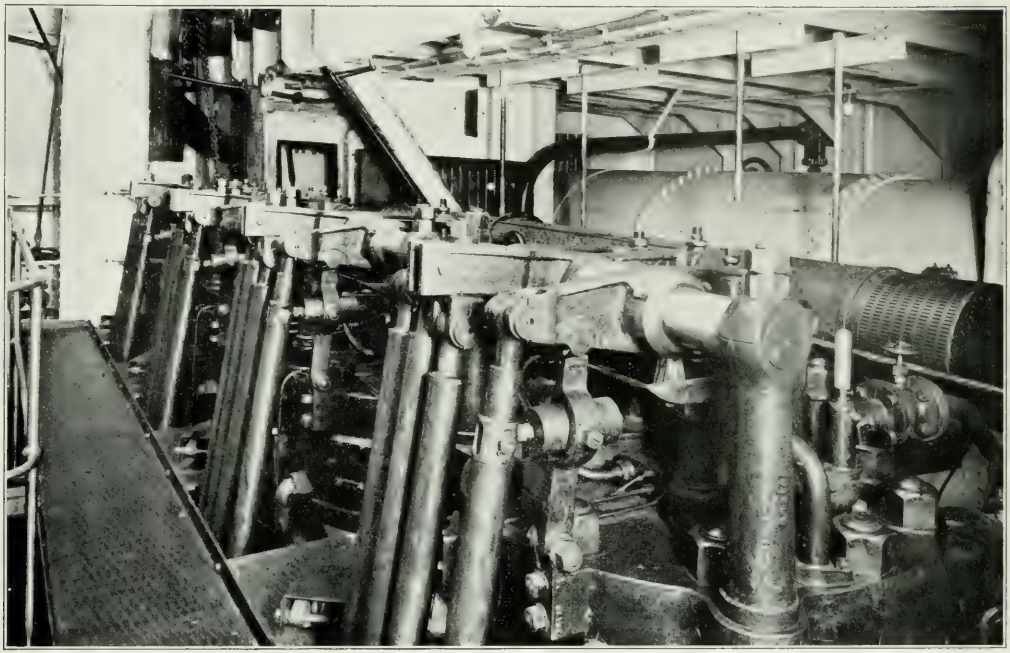
of these controls one set of four cylinders and regulates the supply of starting air or fuel. Thus, in starting, the levers can be placed in such a position as to admit air only to the cylinders, and then, when they are pushed quite over, all cylinders are put on fuel, but usually the sets of four cylinders are not controlled separately, both levers being moved at the same time. Another interesting feature which will be noticed in

Deck View looking Aft from the Forecastle.

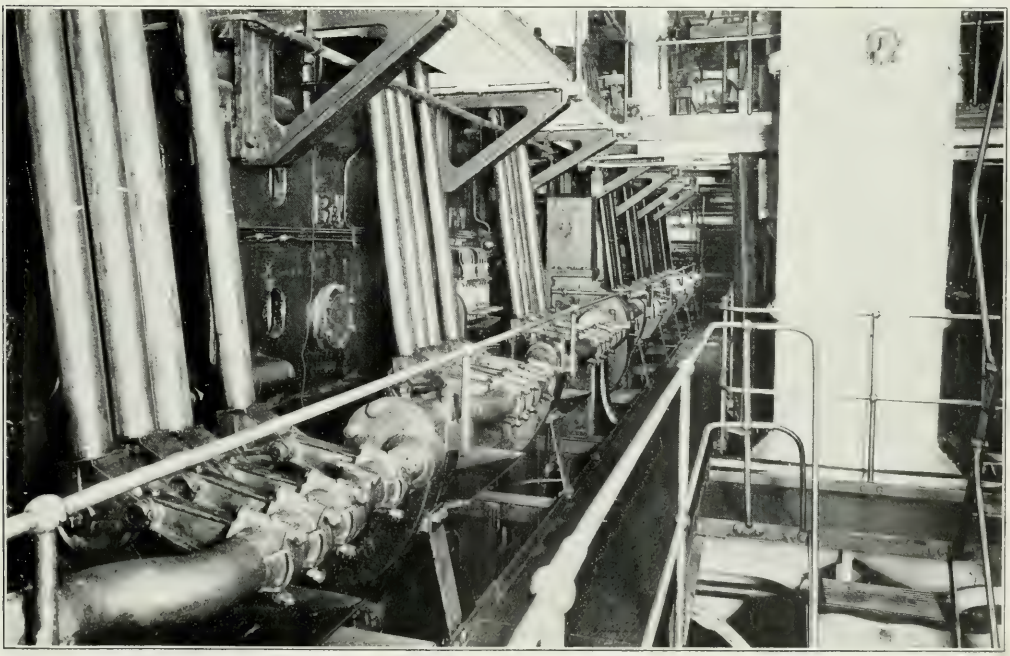


View looking down Engine Room, showing Cylinder Tops of Port Engine.

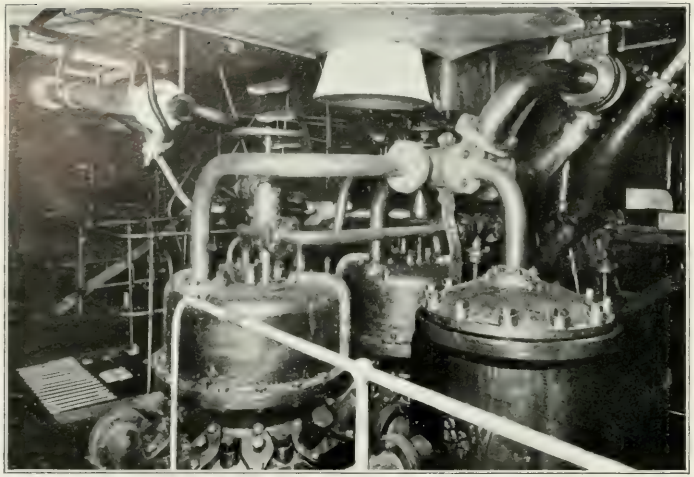
MOTOR CARGO VESSEL "TANTALUS."



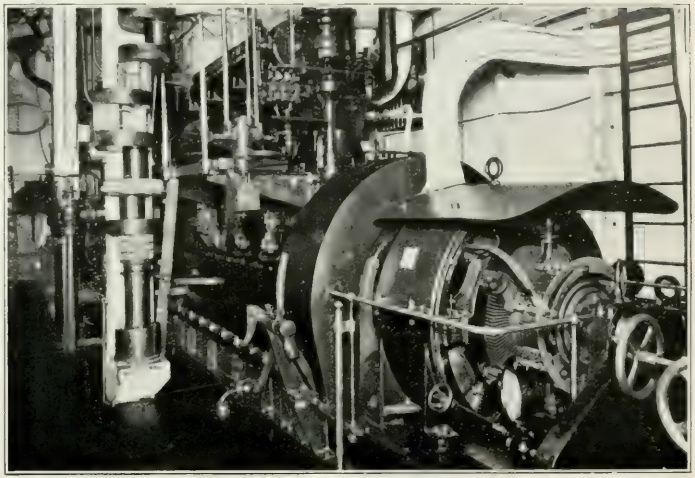
View looking along the Cylinder Tops of the Port Engine.



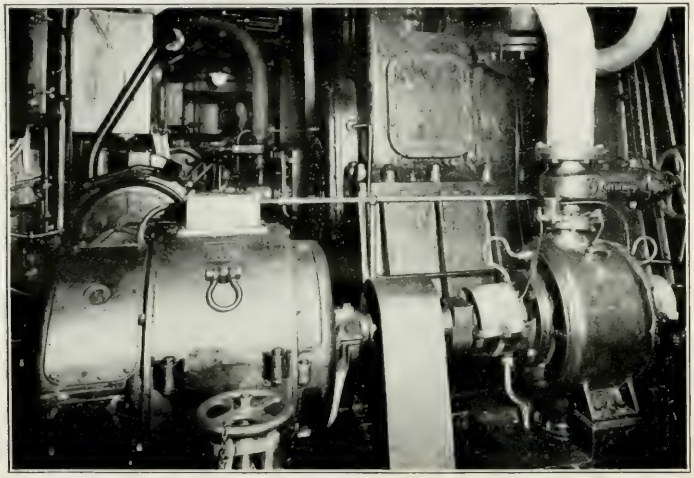
View looking along the Port Camshaft and Reversing Shaft.



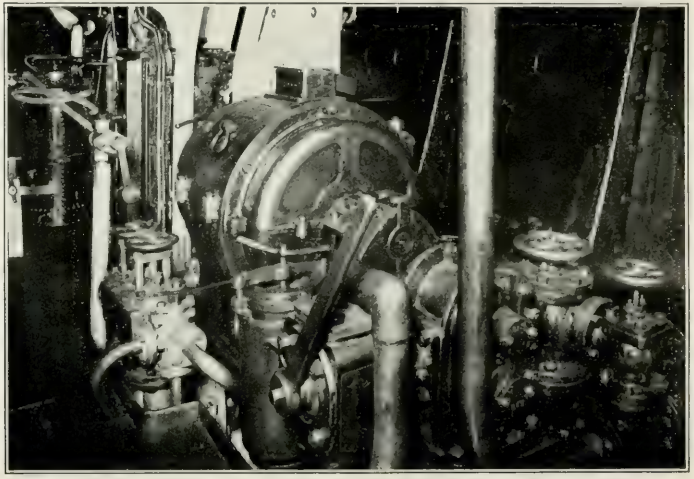
The Blast Air Compressor Tops, Port Engine.



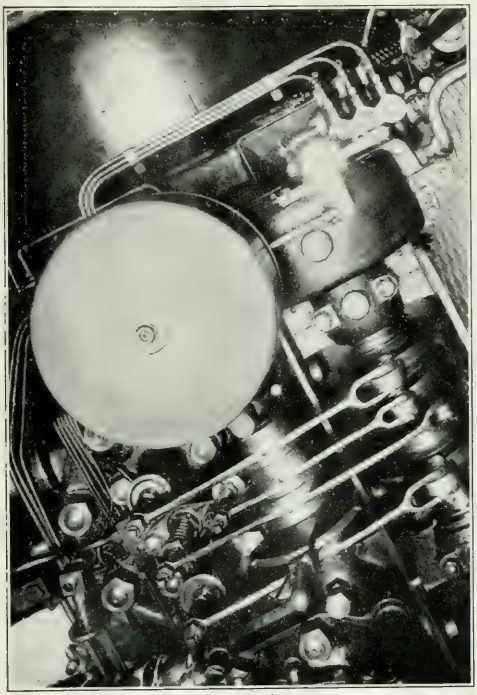
View of the Aft Port Generating Unit.



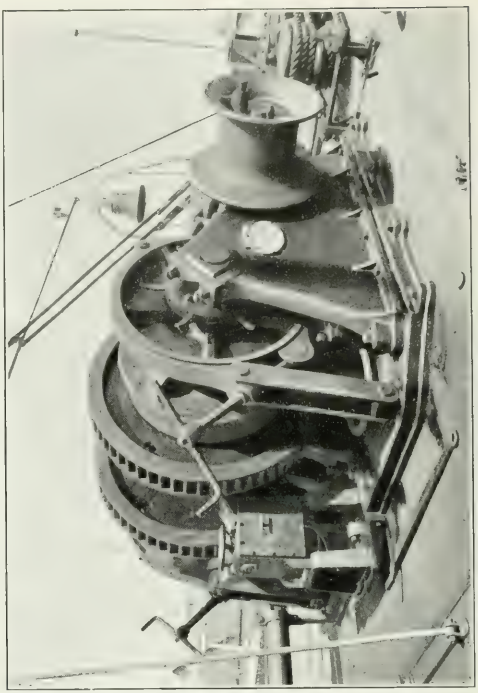
Centre Motor-driven Salt Water Circulating Pump.



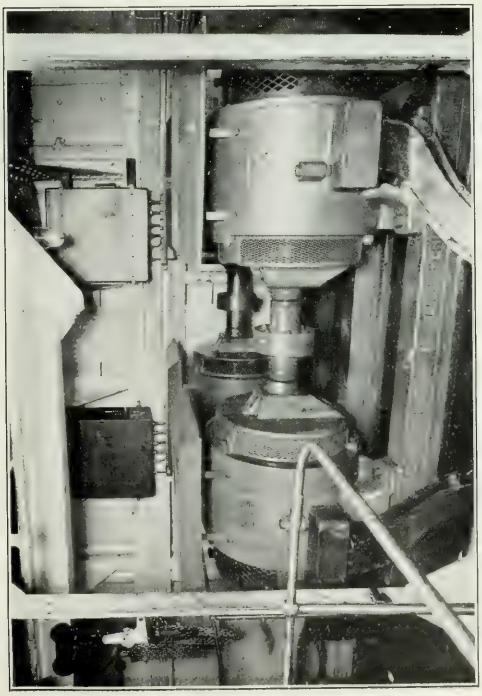
View showing the rotary Fuel Pump between the Main Engines.



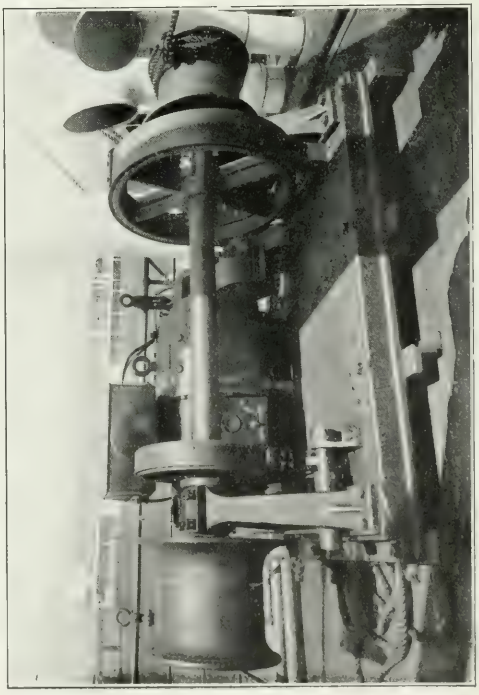
Looking on No. 2 Port Generator Engine.



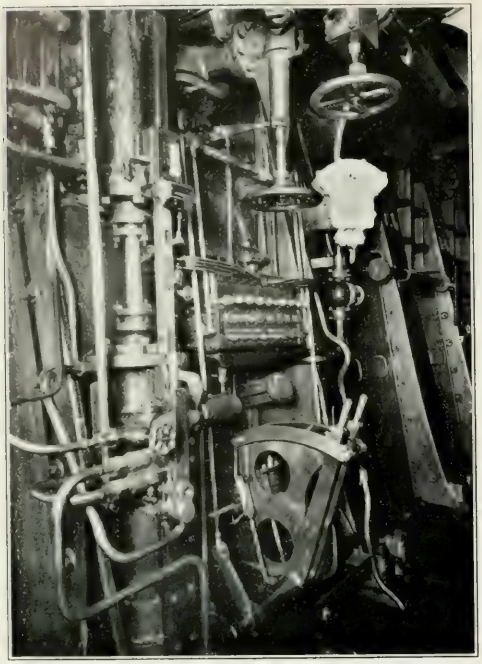
The Electrically-Driven Deck Winch, supplied by John Wilson & Co. Ltd.



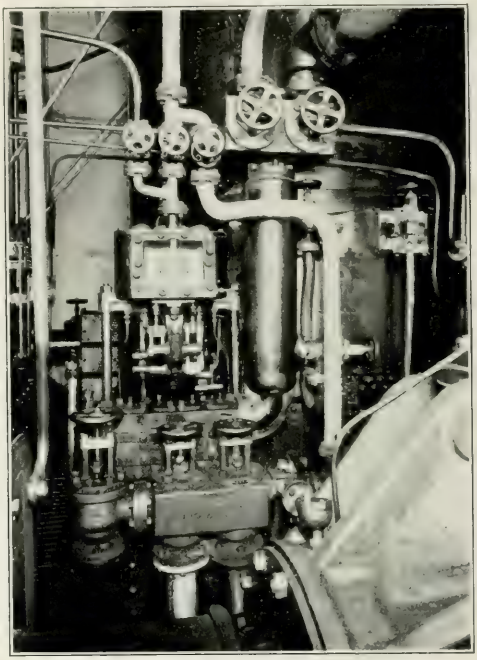
Rotary Transformer, supplied by the Sunderland Forge & Engineering Co.



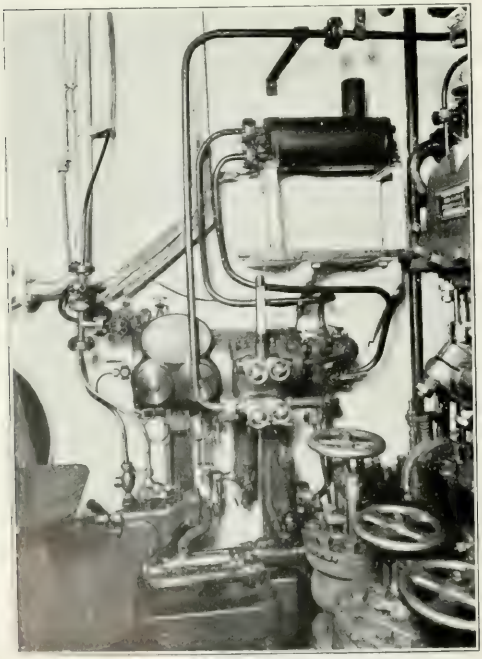
An Electrically-Driven Winch on the Bridge Deck aft.



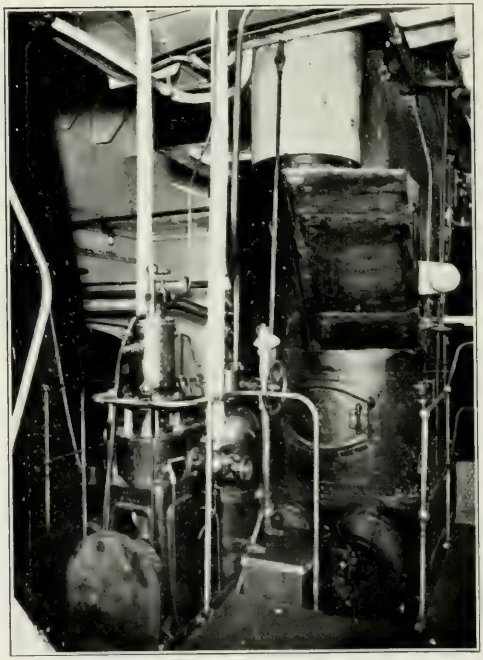
The Port Control and Manœuvring Position.



The Donkey Boiler Feed Pump.



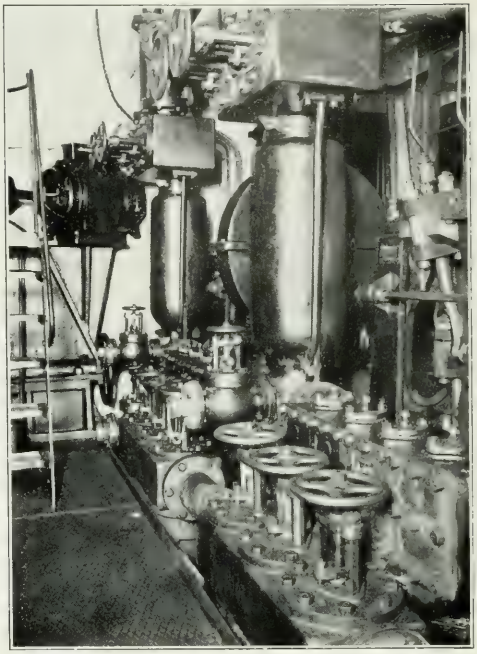
The White Oil Fuel Pumping and Heating Unit for the Donkey Boiler.



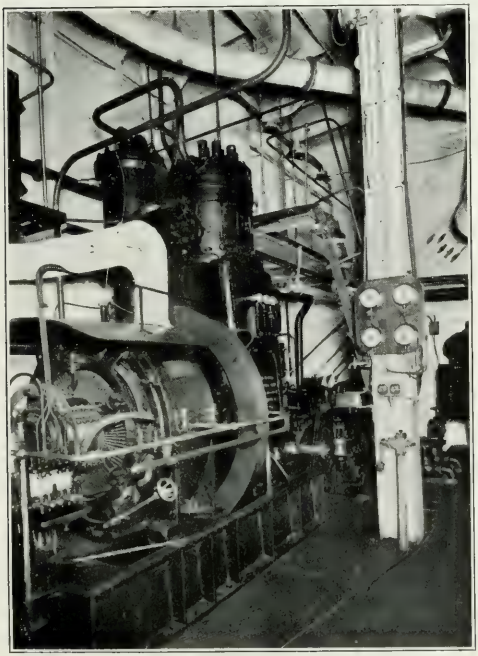
The Steam-Driven Auxiliary Compressor and the Cochran Donkey Boiler.

MOTOR CARGO VESSEL "TANTALUS."

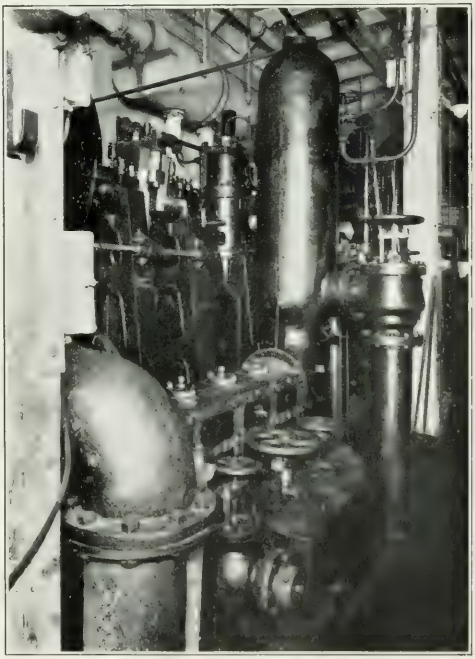
Looking along the Main Switchboard from the Port Side.



View of the Fire and Bilge Pumps on the Port Side. Turning Motor in the background.

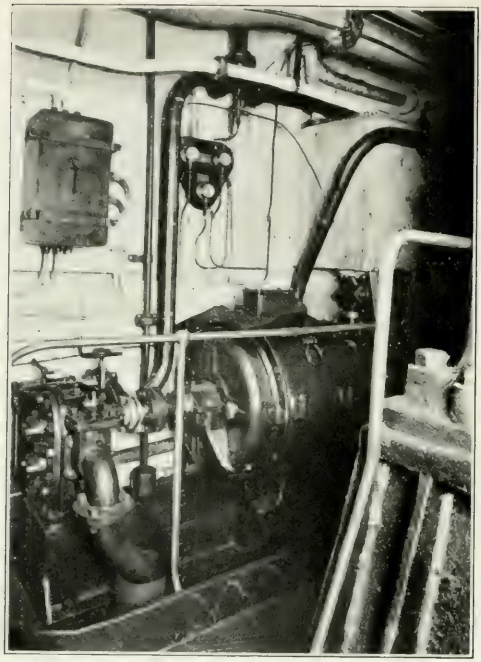


The Motor-Driven Manœuvring Air Compressor on the Port Side.

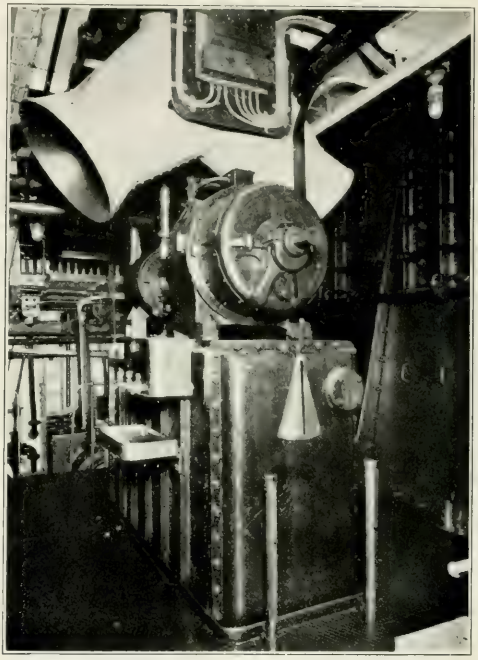


View of the Port Side Motor-Driven Ballast Pumps.

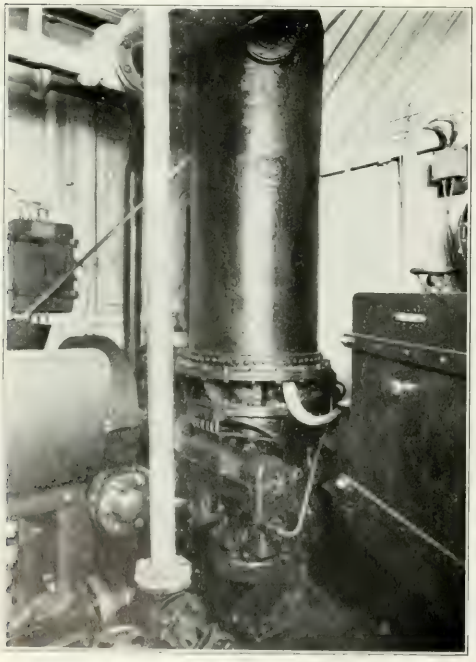
THE MACHINERY OF THE MOTOR CARGO VESSEL "TANTALUS."



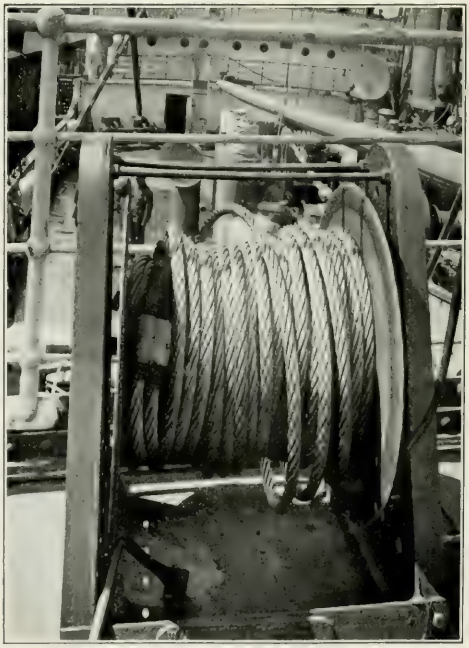
Lubricating Oil Pump, Port Unit.



The Fresh Water Cooler and Circulating Pump.



Drysdale Emergency Motor-Driven Pump.



One of the Wire Reels with Wire Rope, supplied by W. B. Brown & Co.

the photograph is the revolution indicator which shows exactly the revolutions of the engines ahead or astern. This is operated by a small dynamo driven off the main engine, the indicator itself being a voltmeter by Elliot Bros. & Co. Ltd., calibrated to read in revolutions per minute. There is a Michell thrust on each engine. The cooling system in these engines is entirely the reverse of that usually found in British-built Burmeister & Wain engines. In the British engines it will be recalled that the pistons are cooled by fresh water and the cylinder jackets and heads by sea water. In the *Tantalus*, fresh water cooling is employed for the cylinder jackets and heads and salt water for the pistons. The cooling water system will be discussed in detail later. There are two turning motors, one for each engine, arranged at the forward end of the engines, as will be seen in the general arrangement plan. From this it will be noticed that the arrangement of machinery is a very compact one, the principal auxiliary machinery being placed in the wings and at the fore end of the compartment. At the aft end of the engine room, between the main engines, is situated a vertical Cochran donkey boiler, which burns oil on the J. Samuel White patent system, the pumping and heating installation for which we illustrate on page 328. There are three burners to the boiler, which is designed for working pressure of 100 lb. per sq. in. The donkey boiler feed pump is of the Dawson & Downie direct-acting type (6 in. $\times$ 4½ in. $\times$ 6 in.), which can, if necessary, run on compressed air, and we illustrate this also on page 328. The donkey boiler supplies steam also to an auxiliary air compresser, which is arranged immediately in front of it.

Auxiliary Machinery.

A glance at the general arrangement plan of the machinery space will show that there are four electro-generators, two of which are arranged in each of the wings of the engine-room. Each of these units consists of an 150 h.p. Burmeister & Wain engine, running at 300 r.p.m. direct coupled to a dynamo supplied by W. H. Allen, Son & Co., Bedford; the main switchboard is illustrated on page 329. It was made and supplied by J. A. Kinnaird & Co., Glasgow, as also was the auxiliary switchboard, which we illustrate elsewhere; the auxiliary generating station, which is situated in a compartment on the upper deck in direct connection with the engine-room, contains a Gardner hot bulb engine driving a generator supplied by W. H. Allen, Son & Co., Bedford, running at 325 r.p.m., and giving current at 110 volts., *i.e.*, half the voltage for the ordinary ship supply. On the starboard side of the engine room the starting and manœuvring air compressor is arranged; this was supplied by the engine builders, and is driven by an 180 B.H.P. Allen motor, running at 250 r.p.m. On this side of the engine room are arranged also motor-driven sanitary pumps and a Drysdale emergency motor-driven ballast pump, operable from the upper deck, which we illustrate on page 330. On the port side of the engine room, in addition to the two generating sets, are arranged two fire and bilge pumps of Dawson & Downie make, driven by Allen motors, one of which we illustrate on page 329. The motors each develop 40 B.H.P., and are rated at 200-300 r.p.m. when running as series motors or 300-700 r.p.m. as shunt-wound motors. There is also a motor-driven ballast pump of Dawson & Downie make, which we illustrate elsewhere. This is driven by an Allen motor of 50 B.H.P., running at 700 r.p.m. The salt water cooling service is carried out by three motor-driven rotary pumps arranged parallel to each other at the forward end of the engine-room, as will be seen; we illustrate the port unit on page 330. Each of these consists of a centrifugal pump direct coupled to a 17-h.p. Allen electric motor, and there is a similar unit driven by a 20-h.p. motor, arranged between the two main engines for the fresh water circulation; this is arranged directly above the fresh water cooling plant, which consists of a nest of pipes, through which the fresh water is circulated, surrounded by circulating salt water. Lubricating oil is dealt with by duplicate plants arranged against the engine-room bulkhead; the pumps are rotary pumps of Burmeister & Wain type, direct coupled to a 17-h.p. Allen motor, and are arranged in duplicate on each side of the motor. There is a rotary fuel pump of Burmeister & Wain type arranged between the main propelling machinery, as will be seen. This is driven by a 20 B.H.P. motor running at 1,080 r.p.m. Two rotary converters, arranged on the port side of the engine room, on the switchboard platform, are shown on page 327. These were supplied by the Sunderland Forge & Engineering Co.

Deck Machinery.

The deck machinery is interesting in that it is electrically controlled. For cargo handling there are eighteen winches of the 4-ton type supplied by J. H. Wilson & Co., Birkenhead, each driven by a 40-h.p. Laurence Scott motor; the winches are divided into two groups—a forward group and an aft group—each controlled from a contactor house. On page 327 will be found an illustration of the windlass; this is supplied by the winch makers and is driven by an 100-h.p. motor housed directly below it, the drive being taken through bevel gearing and a vertical shaft. The windlass may be used in conjunction with a 40-ton derrick for heavy cargo. The reels for coiling wire ropes, together with the wire rope (*see page* 330) were supplied by W. B. Brown & Co. (Bank Hall) Ltd., Liverpool.

THE IMPORTANCE OF "CLEAN" OIL.

In the lubricating oil system of any type of marine engine, particularly where forced lubrication is employed, special precautions are taken to ensure that the oil entering the bearings shall be entirely free from any foreign matter, and to this end the oil is carefully strained and filtered. The reasons for this are obvious, although it is not usually recognised that they apply almost as powerfully to the fuel oil in the injection system of a Diesel engine. Wherever oil—or any other fluid—passes at high velocity over a metal surface, the presence of the smallest particles of solid matter will lead to scoring of that surface, and thus at the fuel valves, if oil is used which has not been thoroughly filtered, the result will be a rapid scoring of the surface of the valve, or of the surface of the seating, which will lead to ineffectual closing with its consequent evils. In Diesel engines working on the solid or airless system of fuel injection this effect will also be noticed at the fuel oil pumps, and it will, of course, be accentuated throughout the entire system by the fact that such high working pressures are employed. We heard recently of a vessel on which the only trouble experienced in the running of the Diesel engines was due to leaky fuel-pump valves, the seats of which were so rapidly scored that frequent grinding in was necessary, and it was recognised that the trouble was due to the traces of solid matter in the Diesel oil. It is apparent, therefore, that careful filtering is essential in the fuel oil system. The Diesel engine, although it has made and is making steady progress in the marine engineering world, is even at the present time looked upon with distrust by many shipowners. The pessimist is always ready to make the worst of a case, and rumour is always in a position to support him, when a breakdown does occur on a ship fitted with some form of internal-combustion machinery. At the same time those responsible for the development of a particular design are apt, in such a case, to search for faults in the large rather than in the small details. It is therefore of the utmost importance that particular attention be paid to the careful running of the smallest auxiliary in order to prevent the occurrence of trouble such as we have outlined above.

LOW PRESSURE VACUUM EVAPORATORS.*
(Multiple-Effect Film Type.)

By Commander C. A. JONES, U.S.N., and Lieut.-Commander A. M. CHARLTON, U.S.N.

Until quite recently the evaporators used in the Navy have resembled fire tube boilers using high pressure steam for fuel. The evaporator shell contained a comparatively large body of salt water in which was immersed the steam coil. This coil, into which the evaporating steam was led, took on quite a variety of shapes. Some coils were made up of horizontal U-tubes with one or several passes; some had a number of vertical spirals in parallel in which the steam entered at the top, condensed and was led away at the bottom; and others had horizontal straight tubes with front and back headers. In all these types the steam was taken direct from the boilers and reduced to various working pressures up as high as 150 lb. The evaporation of the sea water took place at atmospheric pressure or slightly above and was led to the distillers or auxiliary condensers where it was condensed into water. Great trouble was experienced in these evaporators with scale forming on the tubes. Starting with clean tubes, it was necessary to raise the steam pressure day by day, until to get the capacity of the plant, the limiting pressure on the coil was reached. At this point the plant had to be shut down, the coils pulled out, and the scale removed from the tubes. This scale was very difficult to remove, so that the operation of scaling was very tedious and frequently resulted in injury to the tubes.

With this type of plant little use could be made of the auxiliary exhaust, as with the low pressure available sufficient water could not be produced to render the ship self-supporting. Various experiments were made, using an air pump on the vapour side so that the sea water would be evaporated at a lower temperature and thus increase the capacity of the plant when operating on auxiliary exhaust. In 1912 an evaporator of an entirely new type was installed on the naval auxiliary *Dixie*. Another plant of the same type was installed on the light cruiser *Salem* in 1913. Although these plants were quite satisfactory and produced fresh water of excellent quality no further installations were made on naval vessels until the *Tennessee* and *California* were commissioned in 1920 and 1921. The success of these plants, together with the constant failure of other types of evaporators to operate satisfactorily, led to the adoption in 1922 of this type of evaporator as a standard for naval vessels. The adoption of this standard has resulted in specifying it for new construction as well as the conversion of existing plants, to operate on the new principles involved. The conversion is projected for all ships of the Navy as funds and time permit.

The new standard type of evaporator is based on the patents of Mr. S. Morris Lillie with modifications designed by the Bureau of Engineering, and will be known as the modified Lillie evaporator. These evaporators will use low pressure steam and will be built in multiple effect (double, triple, or

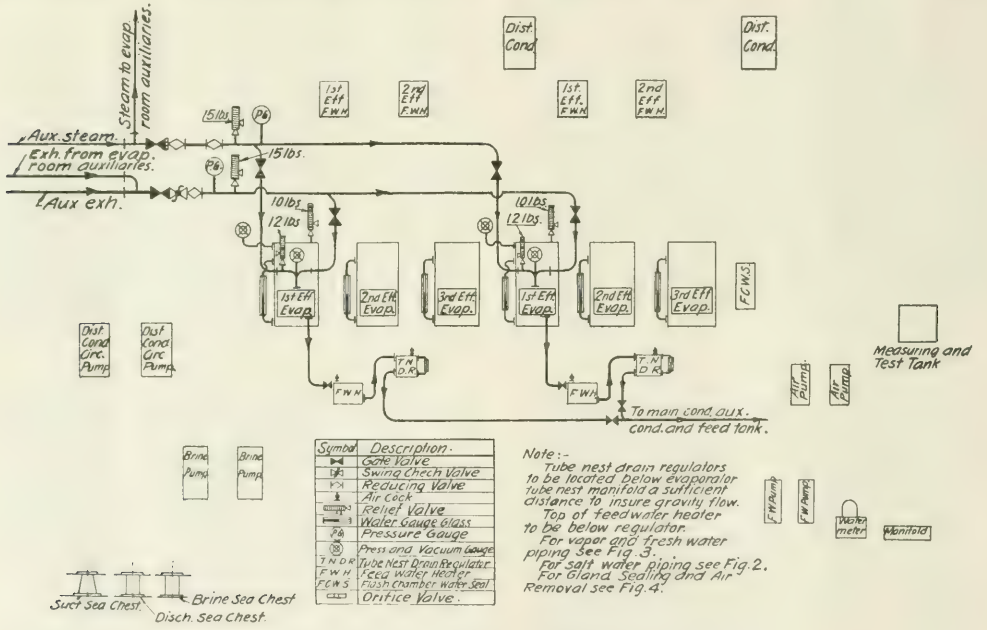

Steam to evap. room auxiliaries.
Aux. steam.
Exh. from evap. room auxiliaries.
Aux exh.
15 lbs.
10 lbs.
12 lbs.
Dist. Cond.
1st Eff. F.W.H.
2nd Eff. F.W.H.
1st Eff. Evap.
2nd Eff. Evap.
3rd Eff. Evap.
F.G.W.S.
Dist. Cond. Circ. Pump
F.W.H.
T.N.D.R.
To main cond. aux. cond. and feed tank.
Air Pump
Measuring and Test Tank
Brine Pump
Symbol Description.
Gate Valve
Swing Check Valve
Reducing Valve
Air Cock
Relief Valve
Water Gauge Glass.
Pressure Gauge
Press. and Vacuum Gauge
Tube Nest Drain Regulator.
Feed Water Heater
Flush chamber water Seal
Orifice Valve.
Note:- Tube nest drain regulators to be located below evaporator tube nest manifold a sufficient distance to insure gravity flow. Top of feedwater heater to be below regulator. For vapor and fresh water piping see Fig. 3. For salt water piping see Fig. 2. For Gland Sealing and Air Removal see Fig. 4.
F.W. Pump
Water meter
Manifold
Suct. Sea Chest
Brine Sea Chest
Disch. Sea Chest.

Diagram showing Steam Lines and First-Effect Tube Nest Drain.

* Abstract of paper read before the American Society of Naval Engineers and published in the journal of that Society.

quadruple). An air pump will be used on the distilling condenser so that the evaporation in the last effect shell will take place in 26 or 27 inches of vacuum. There is nothing new in the above arrangements, all of which have been used before. The method of circulating the salt water feed for evaporation within the shell, however, is entirely different from that at present in use. Instead of having a drowned tube effect with a large body of water in the shell from the surface of which steam is disengaged, the Lillie evaporator uses "film" evaporation, or more properly "rain" evaporation. The feed entering the system is sent through all of the effects in series, finally being discharged overboard with a salinity of 2·5/32ds (2½ times normal salinity of sea water). At each effect a circulating pump takes a suction from the bottom of the shell. Part of this water is discharged to the next effect. The remainder of the water is pumped back into the shell to a point above the tube nest where it is discharged over a perforated distribution plate. From this plate the water descends in a rain of drops over the tube nest. Part of each drop evaporates and the rest of the drop washes the salt remaining from the evaporation off the tubes down to the bottom of the shell. The water level in the bottom of the shell is kept just above the lower row of tubes. With the above method of circulation, "flash" evaporation takes place, there being sufficient extra feed to keep scale from forming in any great quantity upon the tubes. The advantages of the above method of evaporating fresh water are many, of which the following may be mentioned :—

(1) Use of all auxiliary exhaust steam available.

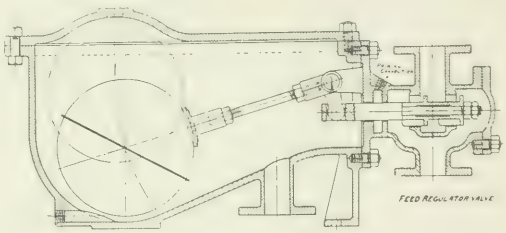
(2) By using low pressures (which means low temperatures) the possibility of the deposit of sulphates on the tubes is practically obviated. This deposit is exceedingly hard and forms a scale which is most difficult to remove. It has been found by experiment that sulphates are precipitated and commence to adhere to the tubes at a temperature of about 265° Fahr. Pressures of 10 lb. gauge (and below), therefore, are quite safe as far as sulphate precipitation is concerned. Below 265° Fahr. only carbonate scale is formed, and the amount of this decreases rapidly with decrease of temperature, and this scale ceases to form at about 195° Fahr.

(3) By using a high vacuum the temperature range between the entering steam and the last effect vapour is large even with pressure below 10 lb. gauge. This temperature range allows the plant to be arranged in triple and quadruple effect, whereas the high pressure drowned tube types were never designed for more than double effect. By the use of multiple effect evaporation the economy is much better than with single effect. Under similar conditions of steam to first effect, vacuum in last effect shell and heating feed water as much as possible with the plant's own available heat, and in every case rejecting the brine from last effect at about 2½/32, we may expect about the following results :—

Single effect—·95 lb. of distilled water per lb. of steam.
Double effect—1·60 lb. of distilled water per lb. of steam.
Triple effect—2·50 lb. of distilled water per lb. of steam.
Quadruple effect—3·30 lb. of distilled water per lb. of steam.

With a constant amount of steam available, which is practically the condition on any one vessel at anchor, the capacity of the evaporating plant is much increased by multiple effect operation.

Steam for the evaporators is obtained from the auxiliary exhaust line or from the auxiliary steam line. Ordinarily there will be sufficient auxiliary exhaust available to evaporate all the water a ship needs. In case there is not sufficient auxiliary exhaust, a high pressure trap should be bled into the main feed heater and the steam thus obtained allowed to back up into the auxiliary exhaust line and so find its way into the evaporators. The use of steam in this way obviates the possibility of superheated steam being used in the evaporators, a condition which would obtain in case boiler steam were sent to the evaporators through a reducing valve. This superheated steam would, of course, have a considerably higher temperature than saturated steam at the same pressure and, as stated before, temperatures over 240° Fahr. should be avoided. After the steam has gone through the tubes of the first effect coil, it is condensed and returned to the main condenser, auxiliary condenser or feed tank for use again in the boilers. This condensate is, of course, tainted with oil, grease and boiler compound, and so is unfit for drinking purposes. To prevent the first effect steam from blowing through the coil, a trap, called the Tube Nest Drain Regulator, is put in the line to the condensers. This regulator maintains a water seal on the first tube nest. The condensate from the first effect coil is quite hot, being nearly at the temperature of the entering steam. The heat in this condensate would be lost if it were returned direct to the condensers and would overheat the feed tanks if led direct to them. To take out all possible heat in the condensate, it is run through a heater through which the salt water feed for the evaporators is also passed. This heater is of the U-tube or bow-tube type with about 50 square feet of heating surface. A by-pass is fitted so that the condensate may be taken away round the heater without shutting down the plant. In order to use a feed heater with this condensate, the tube nest drain regulator is put outside the evaporator beyond the feed heater. A pilot valve, which lifts at 12 lb., is mounted on the steam line to the tube nest at the evaporator shell. A relief valve set at 15 lb. is fitted on the auxiliary exhaust line to take care of surges of pressures

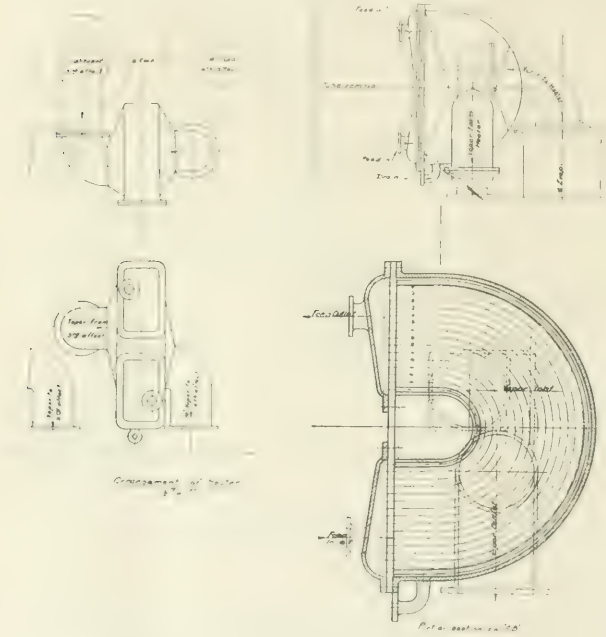


Sketch showing Feed Regulator and Drain Regulator.

in the line due to machinery such as the steering gear. Great care must be taken to keep the feed heater tight as any leak from the salt water side will salt up the boiler feed water. The drain regulator operates on the ball float principle, the movement of the ball up and down opening or closing the valve and so allowing more or less condensed water to flow out of the bottom of the tube nest.

Circulating water for the distilling condensers is taken from the sea by either of the distilling condenser circulating pumps, sent to the condensers and discharged overboard. Inside of the overboard discharge, connection is taken off the discharge line from the distillers and through this connection salt water feed for the evaporators is obtained. A regulating valve is fitted on the discharge line from the distilling condenser so that the temperature of the feed may be kept as high as possible. In case a separate sea chest for the evaporator brine overboard is not fitted, the latter should be led into the distiller overboard line between the regulating valve and the sea valve. If the brine overboard line were connected in ahead of the regulating valve, the brine overboard pump would have an additional head to overcome. At the highest points on the salt water side of the distilling condensers air valves are fitted. These are kept cracked and a small continuous flow of salt water is led away. This will keep the condensers from becoming air bound. The drain should be led to the engine-room drain well and not allowed to flow into the bilge. On its way

to the first effect shell the feed water passes through two vapour feed heaters and one coil drain feed heater. The vapour heaters are interposed between the first and second, and second and third effects, of the evaporator respectively. In a quadruple plant a vapour heater is also put between the third and fourth effects. In some plants there is insufficient room to put the vapour heaters in the vapour lines. In these cases the heaters are placed in the steam heads of the second and third (and fourth) effects. The results are identical. The vapour from the first effect shell goes through the first effect heater on its way to the coil of the second effect. Likewise the vapour from the second effect shell goes through the second effect heater on its way to the coil of the third effect. After going through the vapour heaters, the feed goes through the first effect coil drain heater where its temperature is further raised. The economy obtained by thus using the vapour and first effect coil drains for raising the feed temperature is very considerable.



Sketch showing Vapour Feed Heater (Vapour Line Type).

The types of vapour feed heaters employed are shown elsewhere. By-passes are fitted on the salt water side of these heaters so that a salt water leak will not necessitate a shutdown of the plant. After going through the heaters, the feed passes to the shell of the first effect evaporator through a feed regulator which maintains the feed water level just above the bottom row of tubes. This is a great departure from evaporators used heretofore. From the bottom of the shell a centrifugal brine-circulating pump takes its suction and discharges part of the water to the next effect shell and the other part to the top of its own shell. This latter part is discharged through a nozzle upon a perforated distributing plate which is mounted slightly above the tube nest and completely covers the top of it. The height of the plate above the tube nest is quite important; if put too close to the tubes the vapour pressure of the evaporated water may prevent water from flowing through the perforations of the plate, thus preventing circulation over the tubes.

Various forms of distributing plates have been experimented with in the endeavour to get better circulation and hence more evaporation. One type consisted of a box manifold into which the circulating pump discharged and from which slotted pipes extended over the tube nest. The distribution of feed with this type was very good, but the vapour rising between the pipes entrained so much water that the salinity of the evaporated water was too high. It is necessary to have a distributor which will prevent the vapour generated on the tubes from rising directly up to the top of the shell. By forcing the vapour out at the sides of the tube nest, it must change direction to get to the top of the shell. In other words, the distributor must act as a baffle. Another type of distributor tried was one made in the form of a covered box into which the circulating pump discharged. It was desired to keep this box full and under pressure, thus ensuring a positive head on all the distributing holes in the bottom of the box. It was found, however, that the box could not be kept full unless the size of the holes was materially reduced. This was objectionable, due to the liability of the small holes filling up gradually from scale deposits. The spacing of holes should be such that the streams of water will come down both upon and between the tubes in the upper row. The spacing in the other direction should be close enough so that water will find its way to all parts of the tubes as nearly as possible. Enough circulating water must be sent over the plate to ensure a flow through all the holes without enough excess to allow a spattering from the top of the plate as this excess will be picked up by the escaping vapour.

As the salt water descends through the tube nest, part of each stream is evaporated. The remainder of the stream partially washes off such scale or deposit as may be left from the evaporated water. To examine the tubes for scale and to determine if the circulation is satisfactory, sight glasses are fitted in each side of the evaporator shell. These glasses will be about 10 inches in diameter and fitted so that the frames may be removed from the shell. The advantage of such a method of observation is obvious. Some scale does form on the tubes, but after a certain thickness has formed it will crack off and drop to the bottom of the shell. If these pieces of scale were allowed to get into the brine-circulating pump they would clog it up, and if discharged back to the distributing plate would choke up the holes. To prevent this clogging by scale a sump tank is fitted at the bottom of each evaporator shell. It is seen that scale which cracks off the tubes falls to the bottom of the sump from which it can be removed through a cleaning door. A horizontal screen prevents any scale being carried to the pump by the velocity of the circulating water. The screen must be removed and cleaned frequently and the scale should be removed from the sump at the same time.

That part of the salt water not discharged back into the first effect shell goes to the second effect shell through a regulator where it, in turn, is partly circulated and partly sent on to the third effect.

In the third effect that part of the water not circulated is discharged to the suction of the brine overboard pump which sends it to the sea.

The amount of water taken into the system depends on the concentration of the brine in the last effect and on the amount evaporated, the feed regulators maintaining a constant level in each of the evaporator shells. The valve on the line leading to the brine overboard pump should be regulated so that the

(*Concluded on page* 338.)

THE GAS TURBINE AND MARINE PROPULSION.

Conflicting Views—Possible Economy—Advantages of the Internal-Combustion Turbine in Marine Work—Some Disadvantages in Recent Designs.

While the internal-combustion reciprocating engine has now been developed to such a very high standard of efficiency and reliability that, in respect of these essential qualities, it is, compared with the steam engine or steam turbine, far superior in the former and no less dependable in the latter, there is, nevertheless, a feeling engendered in the minds of many by the qualities and performance of the steam turbine that history may repeat itself, and that in the course of mechanical evolution and progress a turbine engine working on an internal-combustion cycle will eventually prove to be a formidable competitor with the reciprocating oil or gas engine. There are, however, at least two very distinct schools of thought in this matter, and by far the largest, which undoubtedly includes some of the greatest authorities on turbine design in this and other countries, seems to be unreservedly of the opinion that the internal-combustion turbine is unlikely to be seen in practical commercial operation for many a year to come. Included, however, in this school is a numerous body who have not studied the question but prefer to leave the matter entirely to others. A small minority, on the other hand, take a far more optimistic view of the possibilities and probabilities of such a prime mover being forthcoming at a comparatively early date, and it would appear that the reasons underlying this view, besides being based on long study as well as on experiment, are that while the serious mechanical difficulties arising from the continuous and uninterrupted use of high temperatures in the turbine—as opposed to their intermittent and their almost instantaneous application in the case of piston engines—were insuperable in the past for lack of suitable material, recent improvements in alloy steels and in their heat treatment, together with greatly increased knowledge of their properties at high temperatures, have so very greatly reduced these early problems that the really formidable ones may now be very largely discounted. In addition to the much improved quality of materials, very great advances have been made in knowledge of turbine design and particularly of designs to suit very severe steam temperature conditions. Since the internal-combustion turbine was widely experimented with in Great Britain some twenty years ago, the temperature and pressure used in steam turbine stations has advanced from about 500° Fahr. and 180 lb. to 700° Fahr. to 800° Fahr. and 250 lb. to 350 lb., and meanwhile the gap between experiment and the construction of large practical gas turbine units* has been very conveniently bridged by the work which has been done abroad, particularly in Germany, and which latter especially has afforded some most valuable information as to what can be accomplished as regards certain essential parts which are common to any I.C. turbine design.

At the present time, however, the introduction of the internal-combustion turbine is beset with certain difficulties even more formidable than those of a purely technical nature. Even an experimental machine capable of developing a thermal efficiency comparable with ordinary gas engine practice is to-day a somewhat unwelcome innovation. It comes at no such fortunate physchological moment for itself as did the steam turbine a quarter of a century ago, and yet its present position even compared to the established types of oil or gas engine is quite comparable with the position of the marine steam turbine versus that of the piston engine in, say, the year 1900. Some very important steamship lines have never taken kindly to the steam turbine but have adhered very consistently to the piston engine. A very serious objection which the I.C. turbine has to face lies in the fact that the widespread undertaking of reciprocating oil engine manufacture by the large marine engineering firms has in all cases involved considerable initial expenditure, and the aggregate sums expended by individual firms on licence rights, preparation of new drawings and plant, on the construction and extended testing of large experimental units, and all the costs incidental to the preparations necessary for manufacturing a new type of engine on a commercial scale have in some cases proved to be very heavy indeed. Advisable and necessary as may have been this development work during the last three or four years, it has been a heavy drain on resources otherwise seriously depleted by the prevailing depression, and the broad fact that further expenditure on marine engine development is not to be contemplated at the present juncture is probably a far stronger reason against the likelihood of an I.C. marine turbine being constructed in Great Britain at an early date than is any technical difficulty. The same argument applies with almost equal emphasis to general engineering firms in this country; expensive experimental work cannot reasonably be undertaken during a period of peculiar trade inactivity and advanced costs of production, nor can it be considered until the out-of-pocket costs of taking up the development of the existing reciprocating types has been largely written off.

Possible Economy.

Supposing for the moment, however, that among some of the many designs at present available—and some of them are of very striking originality—the mechanical difficulties, which are mainly concerned with the influence of temperature on the scaling properties of the nozzles and the blade material and on its influence on the elastic strength of the rotor material, which must essentially run at a peripheral speed far in excess of the highest existing marine steam practice, can be regarded as being very largely overcome in view of the developments in recent years in heat-resisting alloy steels, what then presumably are the advantages which an internal-combustion turbine is likely to offer for marine purposes? It is most necessary to consider the matter from this point of view before attempting to arrive at any conclusions as to whether the prize in view is likely to be worth the risk of the expense of development.

Very obviously, if the question of reliability be temporarily accepted as suggested in order to admit of a starting point for discussion, fuel economy must exercise a very determining influence on the future prospects of the I.C. turbine whatever may be the general features of the design. Equally so for marine purposes, the use of producer gas as fuel seems almost to involve as much experiment as does the I.C. turbine itself, and broadly speaking, only the heavy oil-combustion turbine can be assumed to be suitable. Only one turbine using this fuel has recently been constructed: this was a 500-h.p. Holzwarth machine built in 1921 for the Russian State Railways. (It is proposed to describe this machine later.) Both Holzwarth and Professor Schüle, of Gorlitz, for him, claim that a brake thermal efficiency of about 25 per cent. has been obtained from turbines working on the constant-volume cycle built to the former's designs, but have given no precise figures of fuel consumption per brake horse-power, though such an efficiency represents a figure of between 0·55 and 0·6 lb. of oil per b.h.p.

* The completion of a 5,000 kw. 1,000 r.p.m. Holzwarth gas turbine was announced in the March *Marine Engineer and Naval Architect*, p. 80.

per hour, and this can be of ordinary fuel oil quality and not a special Diesel oil. With the current respective prices at £3·25 and £4 per ton—the price of the former is roughly about 80 per cent. of that of the latter throughout the frequent fluctuations—the fuel *rate* per b.h.p. for the same *cost* per b.h.p. would, in the case of a large Diesel using special Diesel oil, correspond to 0·44 to 0·48 lb. per b.h.p. against the 0·38 to 0·42 of actual practice. That is to say, that even crediting the oil turbine with the ability to use the cheaper class of oil—Holtzwarth has burned even tar oil in his first experimental turbine—the most optimistic view that can be taken of the respective fuel cost per horse-power as between the turbine and the existing marine oil engine is that the former, at its present best, is some 15 per cent. more costly.

In what is perhaps an optimistic vein, Mr. W. A. Forbes, R.C.N.C., has claimed that "operating on the Hepburn-Forbes (internal-combustion turbine) system, the calculations, in which reasonable allowances have been made for losses, show that an overall efficiency approximating to that of the Diesel engine should be obtained and that there is therefore a wide margin between this value and the efficiency of the very best steam turbine." In the case of land work for purposes of electric generation this margin between the two types will probably prove eventually to be very satisfactory for the I.C. turbine. The best thermal efficiency of steam turbine only so far obtained is only just 25 to 25·5 per cent., but the overall efficiency of the plant is reduced to about 20 per cent. by the influence of the boiler installation, and very few stations indeed have so far exhibited more than this on test. In service performance very few indeed exceed 17 per cent. But for marine work the reciprocating oil engine nowadays covers such a vast proportion of the world's tonnage in engine powers of well-proved efficiency that the comparison must not be drawn with the best steam turbine practice but with the oil engine. On land, the conditions are somewhat different, and the heavy oil engine is unsuitable for driving large power alternators. It is true that the oil turbine offers some considerable scope for the application of internal-combustion machinery to vessels of types for which the large size and weight and restricted power of the oil engine render it unsuitable, but the efficiency of some oil-fired geared turbine installations is very high. One of the best results for oil consumption per b.h.p. for all purposes with which we are acquainted was the case of the U.S.T.B.D. *Pruitt*—a vessel of remarkably high efficiency in all sections of her propelling plant. She obtained a b.h.p. for 0·823 lb. of 19,124 B.Th.U. oil, or a heat consumption per b.h.p. of only 15,740 B.Th.U. per hour, which represents a brake thermal efficiency (auxiliaries included as in the above power station results) of 16·2 per cent., or somewhere about half of that of a Burmeister & Wain or Scott-Still-engine. The s.h.p. of the *Pruitt*, however, was some 27,000 on two shafts, or far beyond the range of any I.C. marine machinery at the present time. It is further still beyond the dreams of any designer of I.C. turbines, and it is very doubtful indeed, even with the assumption of mechanical reliability made above, whether an oil turbine installation could be made to compete with the weight of a steam plant in this class of ship even when weight of machinery plus weight of fuel for a given radius is taken into account. Comparisons, therefore, should only be made with very great care; it is possible that in the case of a 27,000-h.p. liner the weight of oil turbine machinery would be considerably less than that of a corresponding steam plant, but progress will be made in oil engines long before this stage is reached with the oil turbine and the question of relative fuel economy then occurs again.

Another group of investigators who are working on a modified constant-pressure cycle has stated that it is not their intention, at first, to attempt to work below about 0·6 to 0·65 lb. of good boiler per b.h.p. per hour pending further experience as to continued reliability with the temperatures then involved, but that it is anticipated that if this consumption is obtainable with adequate working reliability it will be possible to considerably reduce this figure after a little experience has been gained. That it is possible to obtain this efficiency *on test* is regarded as almost indisputable; that with the temperatures then obtaining there seems little doubt that the mechanical reliability will be ample *on test*, but the real question which remains to be solved is the length of time over which these qualities will be maintained. In the case of this design the estimated economy has been deliberately sacrificed in order to attempt to secure greater continued reliability. It is very probable that on a short test a figure as low as 0·5 to 0·55 could be obtained, but not maintained owing to the influence of temperature on the properties of durability of certain parts.

Now whereas the big oil enginew ill produce a b.h.p. for, say, about 0·4 lb. of oil per b.h.p. per hour, it will do this when running in either direction, and no gas turbine design with which we are acquainted seems even faintly likely to be reversible even in the sense in which the ordinary steam turbine is reversible, *i.e.*, by the incorporation of a separate astern portion. The only possible scope for a marine I.C. turbine seems likely to be in conjunction with an electric system of independent generators driving motors on the propeller shafts. Opinions differ regarding the merit of this form of gearing, but with the exception of the Föttinger hydraulic gear it would seem to be the only feasible solution. In either case there will be a material loss of energy between the turbine and the propeller shaft which it is not unreasonable to put at, at least, 8 per cent., against which, however, the freedom of choice of propeller revolutions which the electric drive affords may offer some slight gain in screw efficiency due to the ability to use coarser pitch screws at lower revolutions than can usually be adopted in the case of reciprocating oil engines where to restrict size and weight, finer pitch screws and higher revolutions compared with good steam practice are always necessary. This additional source of loss on the top of a b.h.p. cost already greater by 15 per cent. brings the excess to at least 23 per cent., ignoring any possible propeller gain, and it is not unreasonable, therefore, to assume that on the score of fuel economy alone the internal-combustion turbine as it stands at present—which is mainly on paper—will be anywhere from 20 to 30 per cent. worse than the heavy oil engine.

Possible Advantages.

Lack of economy need not entirely outweigh certain advantages which are inherent in the turbine as opposed to the piston mechanism. All the advantages which the steam turbine possesses cannot be reproduced in the case of the internal-combustion turbine for the simple reason that in the latter it is impossible to extend the cycle limits beyond those employed in the I.C. piston engine on account of temperature difficulties. With steam, both higher superheat and lower vacua were possible, and this extension first counterbalanced and then outweighed the inherently lower efficiency of the turbine compared with the piston type of engine as regards efficiency of energy conversion. With I.C. gases, there is no use in going below a certain exhaust temperature as will readily be seen by reference to an entropy chart, and hence the only way of extending the cycle is to increase the initial temperature and this the I.C. turbine will not stand. Hence a very similar ratio of expansion must be used in both engine and turbine, and the lower mechanical efficiency of the latter renders economical equality out of the question in the case of the I.C. cycle.

The other advantages of the turbine system, however, do remain in no uncertain form. Lubricating oil consumption, which is always a heavy item in engine work, will be reduced to a very small quantity. There will be no more vibration than with the steam turbine. Stresses in shafting will be very much lessened. It is probably impossible to reduce personnel as this is already at what is practically a minimum in existing oil-engined ships. These items are but a small set-off against the lower fuel economy. It is rather in the direction of reduced

weight and space occupied that compensation must be sought, and here the oil turbine should show to very great advantage. As regards weight, it seems indisputable that this will be enormously reduced. An I.C. turbine must necessarily run at relatively high revolutions for the power in order to reduce a number of detail difficulties due to temperature which do not occur in the case of steam, and it will, at first in any case, necessarily be a single wheel type of machine and not one involving wheels in series separated by diaphragms because the impinging temperature on the blades of the first wheel, if the temperature drop be halved, would be far in excess of what experience has shown to be safe. This feature involves a relatively small and light turbine for the power. It also reduces the overall length; it entails small individual weight of parts. Engine room length and height are reduced, and the massive foundations necessary for the large oil engine are very largely obviated. The precise comprehensive advantages, then, can only be estimated on the merits of each case and naturally differ with type of ship, but the large reduction in weight and space extends the possibility of fitting internal-combustion machinery to types of vessel to which it has, for this very reason, hitherto been inapplicable. These classes would include warships other than torpedo craft, channel steamers, yachts and a few light fast craft, as well as other vessels in which the ratio of power to displacement is high.

Some Disadvantages and Difficulties.

The foregoing section is deliberately based on an assumption of working reliability for certain designs which have been elaborated during the last three or four years. Even with this optimistic and gratuitous start it cannot be said that the apparent advantages are very great compared with the increase in fuel consumption economy in relation to the oil engine. Even the reduction in cost due to the elimination of heavy forgings and castings and the truly enormous mass of small and highly expensive details connected with the valve gear of the oil engine is not an adequate set-off against the fuel bill.

The principal disadvantages in the way of applying the gas turbine to marine work depend very largely on whether it is designed to work on a constant-pressure or a constant-volume cycle. Either type possesses distinctive pros and cons. The great simplicity of the former system has undoubtedly been the attraction which has led many designers to restrict themselves entirely to this pattern. An internal-combustion turbine working on this cycle must consist essentially of the following parts :—

(1) A furnace in which the combustion takes place, the gases leaving this and passing,

(2) Through nozzles on to the turbine wheel. This turbine wheel must generate sufficient power to produce an effective surplus of available work after the quantity necessary for driving,

(3) The air compressor is deducted.

This compressor supplies the quantity of air necessary for the combustion of the fuel (oil or gas) at such a pressure as may be desired. If the cycle is entirely super-atmospheric, then the turbine must exhaust at a pressure slightly above the atmosphere and the whole of the pressure drop must be furnished by the compressor.

Alternatively, the fuel may be burnt at atmospheric pressure and the compressor may be used as an exhauster, the entire pressure drop taking place on a sub-atmospheric cycle, the exhauster drawing the necessary air from the atmosphere into the furnace and through the turbine and discharging the burnt gases to the atmosphere.

Or, a combination of the two resulting in a super- and sub-atmospheric cycle may be used.

The difficulties in the way of this design may be taken in the following order :—Suppose the expansion from furnace temperature to exhaust temperature be adiabatic, then with a given exhaust temperature T_2 (of say 700° Fahr. to 900° Fahr.) the theoretical furnace temperature T_1 will be approximately : —

$$T_1 = T_2 \left(\frac{P_1}{P_2} \right)^{\frac{n-1}{n}}$$

where P_1 and P_2 are the initial and final temperatures respectively and n is the index of expansion ; $n = 1 \cdot 4$ for air and rather less for the actual working substance.

Now while the temperature rises with the (compression ratio)$^{0 \cdot 28}$, as this compression ratio rises the difficulties of burning the fuel in the furnace begin. Besides the difficulty involved in burning fuel under high pressure (say 100 lb. upwards) as compared with the action in an oil engine cylinder, the restricted size of the furnace means high gas speeds through it with every prospect of serious erosion of walls, and the particles of furnace lining passing through the nozzles at high velocity have been found to damage the blading considerably. Without a big compression ratio, say at least 12 or 15, the theoretical thermal efficiency will be poor. With a high compression ratio the temperature on the nozzles is high, and with the constant-pressure cycle this application of temperature is continuous. The cooling of the nozzles then becomes essential. This generates steam, and some inventors have arranged to use this in separate nozzles impinging on the same blading in an attempt to mitigate the temperature effect of the gas. The next difficulty in the sequence lies in the fact that unless the compression ratio and temperature are high the amount of work available per pound of fuel is low, and hence the gross work done on the turbine wheel is low, while in order to restrict the temperature the quantity of air required to be burnt and mixed with the products of combustion must be relatively considerable, and hence the work to be done on the compressor is unduly large in relation to the total work available. With small gross effective work and large negative work the amount of net effective work falls off very rapidly indeed. The would-be designer of a constant-pressure turbine, therefore, is faced with an inter-acting series of problems of which the solution of one merely aggravates the difficulties of the next. These, however, are matters of design and construction, and though the most formidable, still do not state the problem in its entirety. In the case of land work, many alternatives are possible which cannot be introduced into marine work. In the latter, operating difficulties are also involved, and manœuvring entails a number of requirements which no other service exacts. Stopping and starting certainly lose much of their force when the electric drive is involved, but the question of governing is then of enhanced importance. It is obviously impossible to instal any valve between the furnace and the turbine; the interior of the furnace is always hot, and when stopped the furnace temperature is unpleasantly close to the turbine blading; and it is not reduced under those conditions to anything like the same extent as it is when the cycle air and gas is expanding through the nozzles. These are merely a few of the difficulties which intrude themselves on to a designer's notice.

In the vast majority of cases it would seem that from an inspection of the patent files the practical conditions of operation in the case of the internal-combustion turbine have been very largely ignored, and that the working substance has been considered as being virtually as easy and simple to deal with as steam. Even if we had to-day a non-scaling steel that would retain high elastic strength at even 1,200° Fahr. for an indefinite period, there are very few patented designs which would offer a good working solution, because in the case of the vast majority the turbine portion only has been considered and not the numerous practical factors which must always be taken into account at the same time. In a further article it is proposed to indicate how these problems have been met and solved by Herr Holzwarth in the case of his constant-volume turbine. Broadly speaking, he has accepted the consequences involved in the utilisation of much greater mechanical

complication in order to obviate the troubles which arise in the case of the very much simpler constant-pressure cycle design such as we have just described. Ingenious as is his solution and practicable as his designs have proved in actual operation, their type does seem likely to have much future afloat.

The fact is that the marine gas turbine stands to be very badly nipped between the oil-fired water-tube boiler and geared steam turbine set and the reciprocating oil engine. The impression that a turbine must be essentially superior to a reciprocating piston engine is dangerously near to being a fallacy; its simplicity is misleading. For powers up to 3,000 h.p. or 4,000 h.p. per shaft it is possible to get an engine that will give a b.h.p. for 0·37 lb. of oil. Experienced designers who are under no illusions in regard to the difficulties of I.C. engine and turbine design will not at present suggest reliable oil-combustion turbines with a consumption of under 0·6 or 0·66 lb. per b.h.p. and if to this be added some further 10 per cent. for the electric or hydraulic transmission which must be fitted in order to render the system reversible, a consumption of close on to double that of the best oil engine seems to be implied. The cost, it is true, may not be so much as this, but the gap is a formidable one to bridge. On the other hand let us, as above, consider the matter in a little more hopeful spirit in order to see what complexion a reduction in consumption might put on the matter, or, *vice versa*, what reduction is needed to do so. Suppose, again, that the anticipated consumption of 0·5 lb. per b.h.p. for the short period during which the mechanical durability of the I.C. turbine would be maintained could be achieved prior to a stoppage due to temperature difficulties. Could anyone regard this as finality? In the early days of steam practice 150° Fahr. superheat was regarded as very high and troubles ensued galore; to-day double the quantity is easily handled. Now 0·5 lb. for the turbine, or say 0·55 with the transmission included, means a corresponding 0·44 in the engine if the relative fuel cost be considered, and with the reduction in initial cost of machinery and foundations as well as in saving of space, the proposition again becomes a much more attractive one. While the present position is the one which has been described, it is rather to the future that one must look, and though to-day the gas turbine as it stands is quite unsuitable for marine purposes the work which has already been done on it has undoubtedly paved the way to eventual success.

LOW PRESSURE VACUUM EVAPORATORS

(*Concluded from page 334.*)

concentration of the brine going overboard is kept at about $2\frac{1}{2}/32$. In the feed line to the second and third effects and in the discharge from the third effect an electric concentration salinity indicator cell is fitted. Leads from each cell are taken to an indicator on which can be read off the concentration of the brine in each effect. The steam made in the first effect shell rises to the top of the shell and passes through a vapour separator to the vapour pipe. Steam enters all around the periphery of the separator, the entrained water being removed by hook-shaped baffles and draining back into the shell through the drain pipe. On its way to the steam head of the second effect, the vapour passes through a heater where part of the vapour is condensed, giving up its latent heat to the feed water passing through the water side of the heater. The remaining vapour and condensate pass together into the steam coil of the second effect where the steam is condensed in giving up its latent heat to the water in the second effect shell. The condensate from the second effect coil passes to the steam head of the third effect coil where it gives up some of its remaining heat. The second effect vapour passes through a separator and vapour heater to the steam coil of the third effect where it is condensed, giving up its heat to vaporise the water in the shell.

The condensate from the third effect shell passes to a flash chamber where part of it flashes into vapour which goes to the distiller. The remainder goes to the suction of the air pump. The flash chamber is fitted so that it forms a water seal, preventing any vapour going to the air pump. The vapour from the third effect shell joins with the vapour from the flash chamber and goes to the distiller where it is condensed. The condensate is taken by the air pump and discharged to the measuring and test tank. In the discharge from the air pump is fitted a distillate salinity cell from which leads are taken to the salinity indicator where the salinity can be measured. Connections are also made to automatic signal lights which show at all times the salinity of the distillate. A white light shows when the distillate has less than ·3 of a grain of chlorine per gallon, a green light shows when the distillate has from ·3 to 5·0 grains per gallon, while a red light comes on when the concentration is over 5·0 grains per gallon. These indications roughly show the limits of water: (*a*) good for the boilers, (*b*) fit for drinking, but not for the boilers, and (*c*) unfit for use at all, respectively. From the measuring tank the water flows by gravity through a meter to the reserve feed bottoms or to the fresh water pumps, which discharge it through the meter and a manifold to feed tanks, ships' tanks or firemen's washroom tanks.

The auxiliaries for the converted plants will all be motor-driven. The distiller circulating, brine circulating, brine overboard and fresh water pumps are single-stage centrifugal pumps direct connected to the motors. The air pumps are reciprocating and connected to the motors by spur or worm gearing. In connecting up and using the centrifugal pumps, care must be taken to keep the glands sealed at all times. If not so sealed, the vacuum will be broken and the glands will overheat and burn out. Care must be taken also to keep the pumps from getting air or vapour bound. If the suction of the pump is not kept flooded, the pump chamber will fill with air or vapour and the pump will refuse to pump. In case this happens, the pump should be primed at once. In installing priming connections they should be arranged as follows: They should be as high up in the suction as possible; they should be as nearly parallel to the suction as possible, and they should be as close to the pump as possible. This will ensure that the priming water will be directed into the suction chamber.

THE AUTUMN MEETING OF THE INSTITUTE OF METALS.

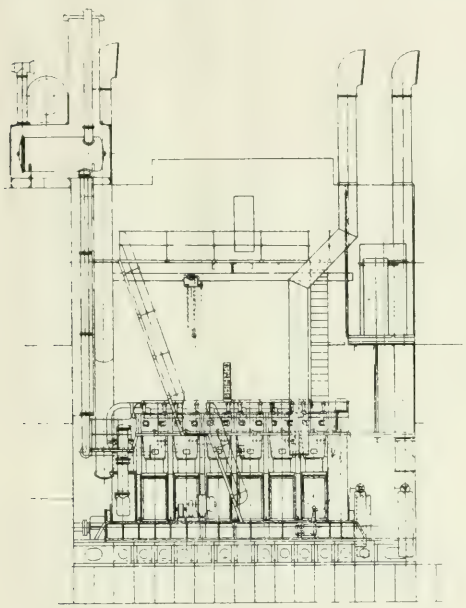
The annual autumn meeting of the Institute of Metals will be held this year in Manchester on September 10-13. The meeting will open with the second annual autumn lecture, to be delivered by Lieut.-Colonel Sir Henry Fowler, K.B.E., on "The Use of Non-Ferrous Metals in Engineering." The mornings of September 11 and 12 will be devoted to the reading and discussion of papers. After an official luncheon on September 11, visits will be paid to several large works in the vicinity of Manchester, and in the evening there will be a reception at the University, when the new metallurgical laboratories will be officially opened. Following the conclusion of the business side of the programme on September 12, the afternoon of that day will be devoted to a trip along the Manchester Ship Canal, and in the evening there will be a smoking concert at the Midland Hotel. With the exception of the autumn lecture, the meetings are open only to members and students of the Institute. For the convenience of applicants for membership, however, who are desirous of being elected in time for the meeting, a special ballot has been arranged, in connection with which membership application forms should have been submitted not later than noon on Thursday, August 30.

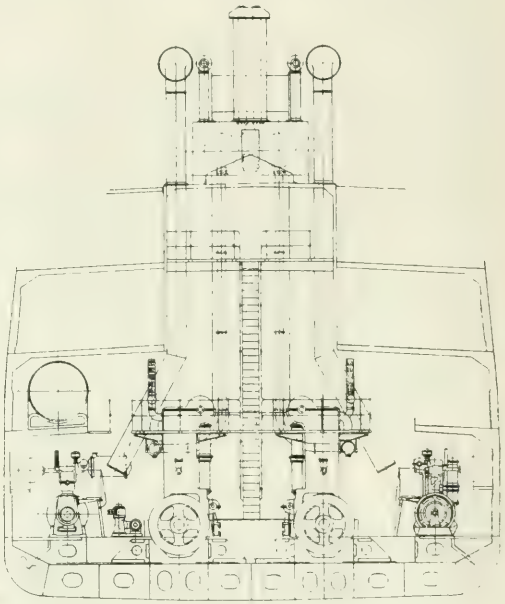
THE TWIN-SCREW MOTOR SHIP "CRUX."

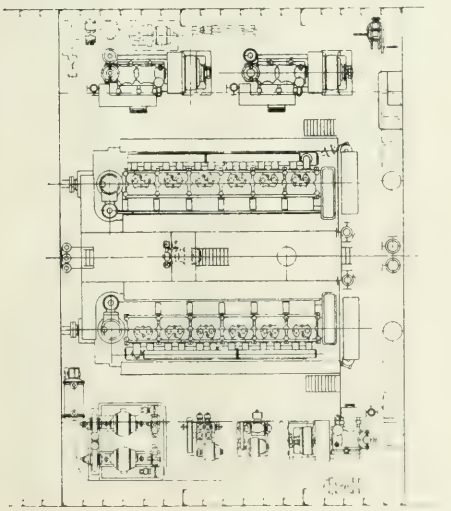
Cargo Vessel of 3,828 tons gross, fitted with Burmeister & Wain's New Light Type Engine.

The twin-screw motor ship *Crux* has been built and engined by Burmeister & Wain Ltd., Copenhagen, to the order of Det Bergenske Dampskibsselskab, Bergen, Norway. She is constructed to Lloyd's special survey to Class 100 A1 shelter deck, according to the requirements of the Norwegian Laws, and, as will be seen from a study of the general arrangement drawings, is built with three complete steel decks, six watertight compartments and double bottom, the double bottom being fitted for the carriage of either fuel oil or water ballast.

The vessel is fitted with two masts and is provided with ten 5-ton derricks. The derricks are served by eight 3-ton







The Motor Ship "Crux." General Arrangement of Machinery Space.

winches; in addition, two 5-ton winches are arranged aft, fitted for warping purposes. The winches are all electrically driven, and have been supplied by the Allmänna Svenska Elektriska Aktb.

The steering gear, which is of Brown Brothers' make, is of the electric hydraulic type and is controlled from the bridge by means of a telemotor. The windlass is supplied by Clarke, Chapman & Co., and is also electrically driven.

The principal particulars and dimensions are as follows :—

Length, overall	382 ft.
Length, between perpendiculars	367 ft.
Breadth, moulded	51 ft. 3 in.
Depth, moulded to shelter deck .	34 ft.
,, ,, upper deck .	25 ft. 6 in.
Height of double bottom	46 in.
Draught, loaded . . .	23 ft. 2½ in.
Displacement . .	about 9,700 tons.
Gross tonnage . . .	,, 3,828 reg. tons.
Capacity of holds—	
Grain	,, 403,000 cubic ft.
Bales	,, 373,000 cubic ft.
Water ballast	,, 1,210 tons.

The general arrangement of main and auxiliary propelling machinery is shown above. The main machinery consists of two six-cylinder four-stroke, single-acting Diesel

engines of Burmeister & Wain's new light-built type for twin-screw vessels, the particulars and dimensions being as follows :—

Cycle of operation	4-stroke.
Number of cylinders	6.
Revolutions per minute	130.
Indicated horse power	2,100.
Stipulated normal average speed at sea	10¾ knots.
Total fuel capacity	1,100tons.
Indicated horse-power, normal	2,100.
Fuel consumption per 24 hours, normal	6·5 tons.

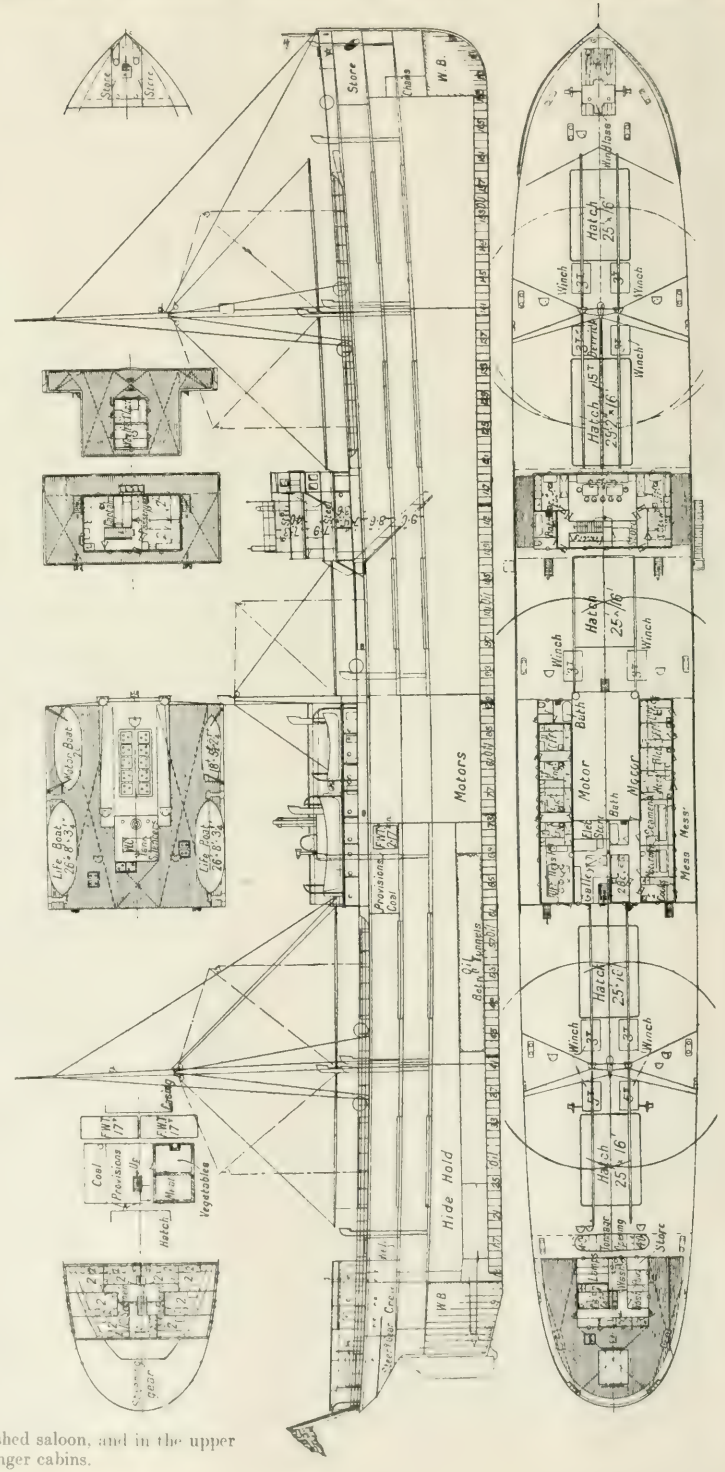
It should be noted that the main engines are normally rated to develop 2,300 i.h.p. at 145 to 150 r.p.m., but owing to the low speed desired by the owners, the horse-power has, in this special case, been reduced to 2,100 i.h.p. at about 130 r.p.m. The daily fuel oil consumption is 6 to 6½ tons, giving the vessel a cruising radius of about 45,000 sea miles.

All the auxiliary machinery in the engine room, as well as the deck machinery, is electrically driven, the current being supplied by three dynamos, one of 33 kw. and two of 66 kw., driven by respectively one single-cylindered and two twin-cylindered auxiliary Diesel engines designed and constructed by Burmeister & Wain. One of these latter is illustrated on page 342. The pressure of the supply for power purposes is 220 volts, but for lighting and heating purposes this is transformed down to 110 volts.

Any one of the dynamos is sufficient to supply the necessary current required for normal working at sea, but two, or even all three, have to be in operation when the vessel is manœvring in and out of harbour with the manœuvring compressor running, or when loading and discharging cargo.

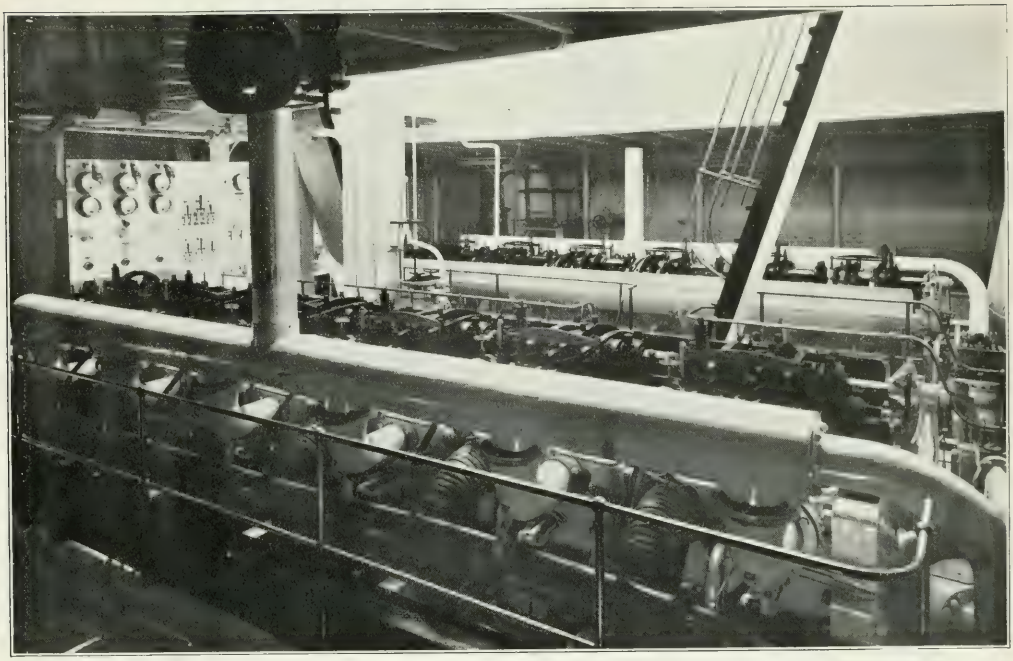
The trial trip was carried out on July 9, 1923, in the Sound at Copenhagen, when a mean speed of 10·94 knots was obtained with a fuel consumption of 129·4 grammes (0·284 lb.) per indicated horse-power per hour, the net calorific value of the fuel used being 10,069 calories per kilogram (18,100 B.Th.U. per pound)). The fuel consumption given above includes the consumption of the auxiliary engines producing the necessary current for driving the auxiliary machinery, the steering gear and the electric light.

In the large deck house amidship there is a comfortably furnished saloon, and in the upper deck house there are a few passenger cabins.

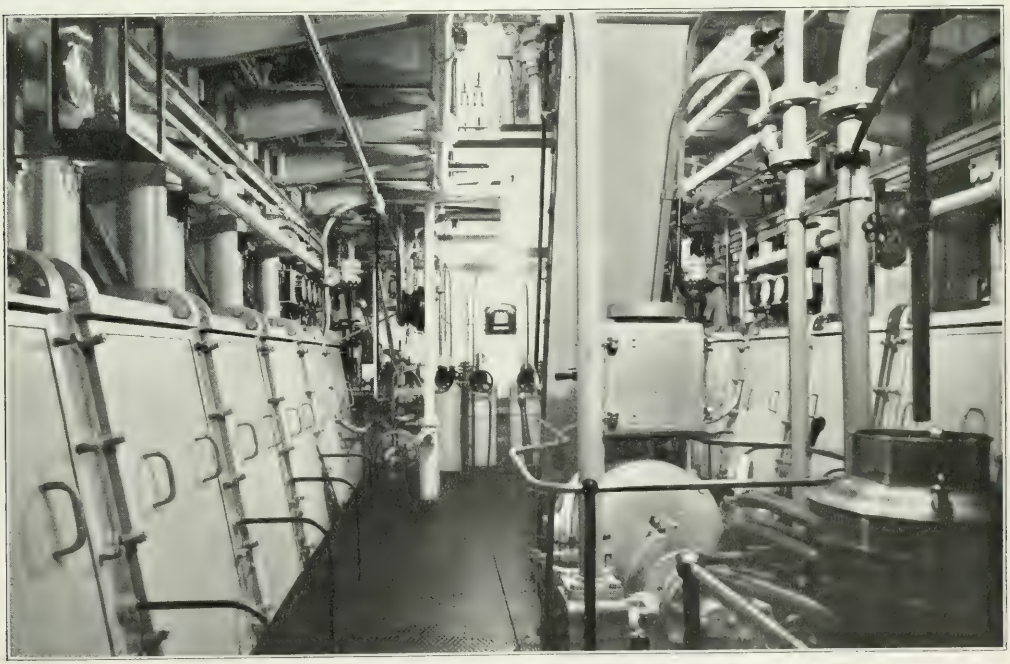


The Twin-screw Motor Ship "Crux": General Arrangement Plan of the Ship.

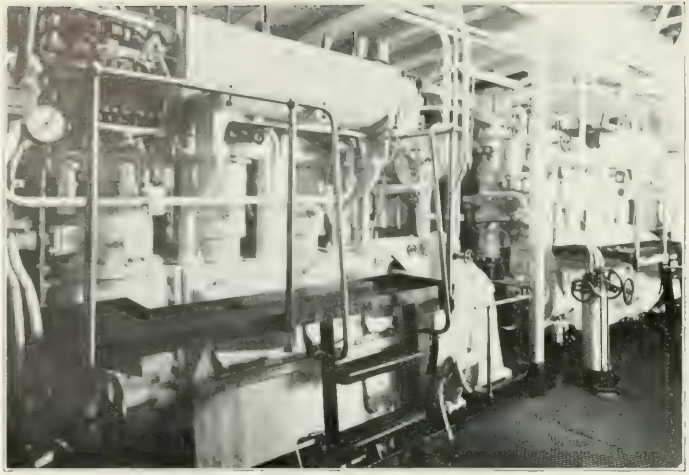
THE ENGINES OF THE MOTOR SHIP "CRUX."



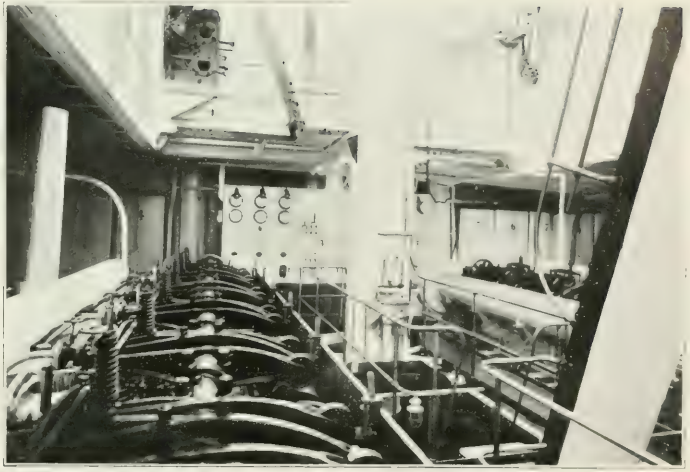
View from the Top Platform, showing Cylinder Heads, &c.



View looking along the Bottom Platform, showing Oil Purifier.

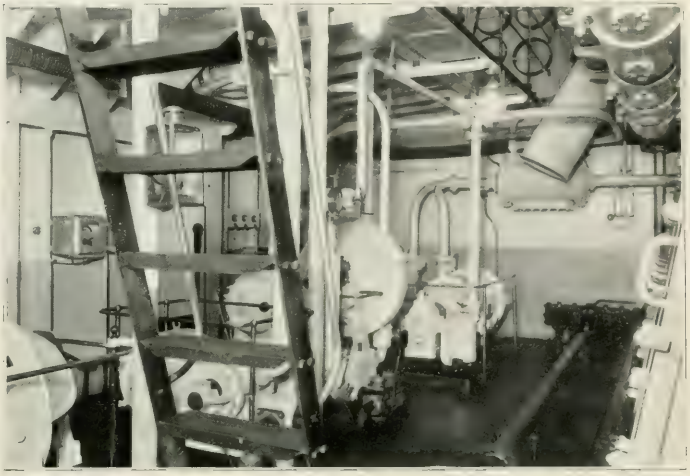


The Aft 66-kw. Generating Set on the Port Side.



The Port Engine Top, showing Valve Gear.

View of the Control Platform of the Starboard Engine.

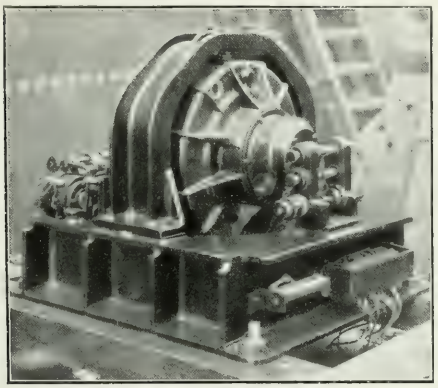


The Aft Starboard Wing of the Engine Room.

THE GYROSCOPE AS A SHIP STABILISER.

The New Sperigyro Ship Stabiliser for the British Admiralty.

The British Admiralty have recently taken delivery of a particularly interesting piece of apparatus, namely, the Sperry Gyroscopic Ship Stabiliser. When this is installed in a vessel it is estimated that the roll under practically all conditions will be limited to about two degrees on either side of the vertical. As will be readily appreciated, this stabilising factor is of special importance to naval vessels, permitting as it does greater accuracy with which guns may be trained and fired, and torpedoes launched. The advantages, too, of a



View of the Control Gyro.

fighting ship with a steady gun platform over an enemy vessel rolling freely are also obvious. There are many unfavourable effects of free rolling in any ship. It is harmful to the ship's structure, for instance, causing severe stresses in the foundations of machinery, funnels, superstructure, gun mountings and all heavy parts of a vessel's equipment, while among many other ill-effects produced by rolling, mention may be made also of a combination roll and pitch, resulting in "yaw," which not only causes erratic steering, but also loss of speed and distance. Under these conditions the steering engine is subjected to ceaseless work, and this is a twofold waste of power—firstly, to a small degree in the steering engine itself, and secondly, to a very large extent in the main engines, due to the brake caused by continual movement of the rudder through relatively big angles. Recent tests have shown that a vessel requires about 1 per cent. additional propelling power for every degree of roll, the extra power being necessary to maintain the same speed as in a smooth sea. In a stabilised vessel bilge keels become to all intents and purposes unnecessary, and thus additional loss of power is entirely eliminated, with economical results.

Roll Quenching Power.

In designing a stabiliser for any ship it necessarily follows that certain basic characteristics have to be taken into account. The principal features of the ship which are required to be known are as follows:—Displacement, metacentric height, period of roll and increment of roll. The design of the stabiliser must be such that its roll-quenching ability equals the maximum roll increment, or full stabilisation cannot be obtained, and the roll-quenching power depends in turn upon the characteristic product $\Delta \times T \times G M$, where

Δ = the displacement.
T = the period of roll.
G M = the metacentric height.

The apparatus itself consists of a main gyroscope, the rotor of which spins with its axle in the vertical fore-and-aft plane of the ship. The rotor and the axle bearings are enclosed in a cast steel case provided with horizontal bearings, so that the whole gyro element can be moved at will about the horizontal athwartship axis. The gyroscope rotor forms part of an electric motor, and is driven at a speed of 1,500 r.p.m. for full power, and the movement of the case containing the rotor is controlled by another electric motor—the precession motor—through suitable gearing. This precession motor is in turn controlled by a small pilot gyroscope, which is very sensitive and responds immediately to the slightest movement of the vessel in the rolling plane. The remainder of the equipment consists of generating plant, switchboards and the lubricating arrangements.

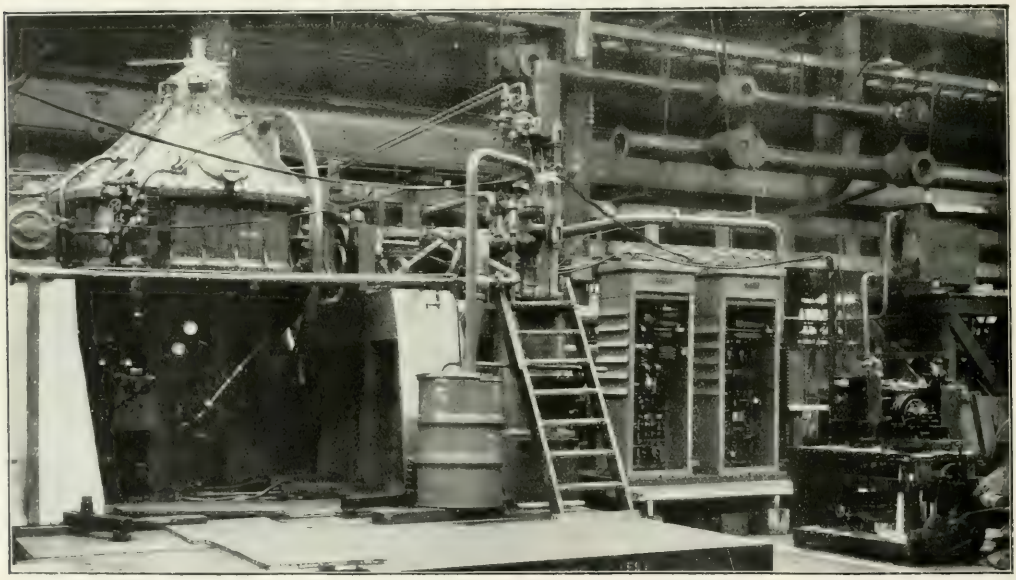
The Principle of the System.

The principle of the stabilising system is to apply a counteracting force just sufficient to neutralise the impulse of each wave as it is received by the vessel. The result is that the ship cannot accumulate any roll, and is kept within about 2 deg. of the vertical. The control gyro is mounted with its spinning axis horizontal and athwartships, and, as will be seen by reference to the illustration, is provided with electric contacts at one end of the gyro axle. This control gyro is so mounted that, as soon as the ship moves in the athwartship plane, one or other of these contacts is closed, depending, of course, on whether the vessel is commencing to roll to port or starboard. On one of these contacts being closed, the precession motor is set in operation in such a direction that the stabilising gyro is caused to move about its horizontal axis in a fore-and-aft vertical plane. When one contact is closed the top of the main gyro and its case will move from aft to forward or *vice versa* if the other contact is closed. When the rotor of the main gyro is spinning, and the gyro case is precessed or moved in the fore-and-aft plane, a couple is applied to the ship's structure through the horizontal case bearings, which corresponds to the disturbing force produced by the wave, and thus the tendency to roll is quenched. In the practical ship stabiliser equipment, the speed of precession must be controlled in order to obtain maximum efficiency for the work done by the stabiliser, and also, incidentally, to limit the gyroscopic forces which are proportional to the precession velocity. This control of speed is characteristic of the active type of stabiliser, and is obtained by a suitable precession motor, brakes and other apparatus. The active type gyro stabiliser practically anticipates the waves, and starts stabilising before the ship has barely moved, and the sensitive element responsible for this action is the control gyro. This is a small gyroscope suitably mounted in bearings, casing and frame, which does not weigh over 150 lb. complete for even the largest vessels. The wheel is revolved by an electric motor at 5,000 or 6,000 r.p.m., and the whole unit can be made so sensitive that it will indicate the ship's roll a fraction of a second after the roll starts. The indication of roll is transmitted electrically to control panels, which operate a precession motor. This motor is geared to the main stabiliser unit, and starts precession of this unit immediately, instead of waiting for the waves to do so, as is the case with a passive type stabiliser. The result is that full stabilising forces are obtained about $1\frac{1}{2}$ seconds after roll starts, and the ship can be stabilised to within 1·5 deg., or 2 deg. roll, on each side of the mean position.

The Stabilising Gyro Unit.

The rotor for the stabiliser is 78 in. diam. by 17·5 in. face, and weighs about 18,500 lb. Its full speed is 1,500 r.p.m. Above half speed the friction of the revolving element in air

becomes quite an important item, increasing almost as the third power of the peripheral velocity. To reduce these windage losses as much as practicable the entire wheel is enclosed in a casing which is exhausted of air to a 15-in. vacuum, thereby reducing the windage losses and saving almost 13 h.p. on this equipment. The entire gyro unit is shown below; this illustrates the equipment during the shop trials in the works of Metropolitan-Vickers Electrical Company Ltd., Trafford Park, Manchester (the sub-contractors), which company manufactured the apparatus to the design and specifications of the Sperry Gyroscope Company Ltd., London. The main bearings and journals which transmit the gyroscopic stabilising forces are prepared in a special fashion to ensure their safely carrying pressures which in ordinary practice are considered quite unusual. The rotor is suspended on a Michell thrust bearing. The main bearings also are provided with



The Complete Gyro Stabilising Unit undergoing Shop Trials.

spherical seats for self-alignment. Oil is furnished to the main bearings and roller bearing at a pressure of about 8 lb. for the twofold purpose of lubrication and cooling of the working surfaces. After draining from the bearings the oil flows to the lower cap at the bottom of the gyro unit, where it is pumped out in a manner which will be described later. An A.C. spinning motor of the three-phase induction type rotates the gyro wheel. The rotor of this motor is mounted on the gyro shaft and the stator on the gyro casing. The stator frame is water-cooled from an outside supply, the water being conducted to and from the motor through flexible connections. Flexible cables swing from the cable entrance to the supply from the switchboard. The entire gyro unit turns freely in the roller gudgeon bearings, any end thrust due to unquenched roll when stabilising or not stabilising being taken up by smaller ball thrust bearings. These gudgeon bearings are the members through which the gyroscopic stabilising forces are transmitted to the ship. The magnitude of these stabilising forces, as stated before, depends upon the velocity of precession. In practice these forces are limited to a known amount by controlling the velocity of precession. This control is accomplished by the precession unit, which consists of the reduction gear unit, precession motor and precession brakes. The reduction gear unit consists of three gear reductions, giving a 110 to 1 ratio between precession motor speed and gyro unit speed. The gears and bearings are lubricated by a small gear pump driven from one of the gear shafts, An auxiliary pump, driven by electric motor, is used to lubricate the bearings until the gear pump is primed. The mechanical brakes are connected in the armature line of the precession motor and release, whenever current is flowing through the motor. When voltage is cut off from the motor the brakes are applied and bring the precession of the gyro to a dead stop in a fraction of a second. The electrical circuits may be divided up as follows :—Spinning motor circuit, precession motor circuit, control gyro circuit, oil and vacuum pump circuits.

The Precession Motor.

The precession motor is operated by a starting panel from the ship's supply. This panel is nothing more or less than a relay reversing switch. The switch coils are energised from the control gyro circuit, and close the circuit through the shunt field to the ship supply. The motor accelerates very quickly and the effect is to bring the gyro up to full speed of precession in about one second. At full speed the motor has the characteristic flat speed-load curve of the shunt motor, and therefore controls the speed of precession within close limits. When voltage is cut off from the motor the armature is braked dynamically by reversing the field across the generator terminals. This, with the mechanical brakes, will stop precession in about half a second. The mechanical brake coils, being in the armature line, act to release the brake shoes when the motor starts, and to apply them when the motor stops. The brakes have sufficient capacity to prevent the gyro from precessing "passively" when the ship is rolling and the precession motor switches are open.

The Control Gyro.

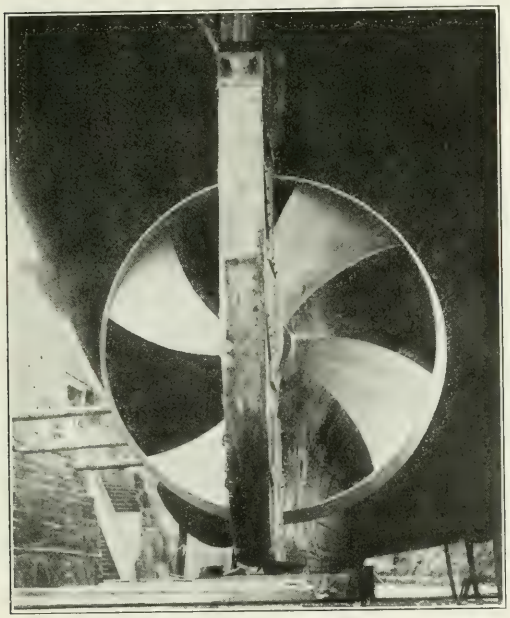
The function of the control gyro is primarily to "pick up" the roll of the vessel and set the stabiliser to work through the precession motor and control. The control gyro motor

(*Concluded on page* 346.)

THE GILL SHROUDED PROPELLER.

Some Notes on its Inception, Characteristics and Application.

The idea that a screw propeller fitted with a shroud should possess advantages over the open screw has occurred to many investigators during more than sixty years past. Attempts to realise these advantages did not, however, meet with conspicuous success, for a screw propeller fitted with a shroud was invariably found to be inefficient as compared with the open screw. Some sixteen years ago the designer of the Gill propeller was induced, by experience of certain propeller troubles, to consider the apparent possibilities of the shrouded type of screw and to attempt an analysis of its defects.



View of the Propeller as fitted to the Salvage Vessel "Ringdove's Aid."

The subject was worked at intermittently during a period of over ten years without any definite advance on the results obtained by former enquirers. When investigating during 1915 the then unconnected subject of flow in nozzles and bellmouths, however, it occurred to the designer that a definite connection exists between the design of particular forms of nozzles giving high coefficients of discharge and that of a shroud correctly applicable to the flow conditions through certain screw propellers. This connection was further supported by detailed consideration of Mr. R. E. Froude's theoretical conception of an imaginary "actuator" and tube.

It received additional justification during 1919 by deductions based on certain experimental results which were published by Sir Charles Parsons and Mr. S. S. Cook. A new series of experiments was therefore commenced with various types of nozzle-shaped shrouds and with model screw propellers, treated both independently and together, with the result that, in 1920, a screw propeller, having axially increasing pitch and a nozzle-shaped shroud of particular form and proportions, was first produced. This propeller gave practical results definitely better than those obtained with certain good typical screws of the open type. It was followed during 1921 by the production of a number of gradually improved screws of the same class and various proportions. During 1922 a consistent series of excellent results was obtained with such propellers, fitted to a great variety of craft and ranging from 1 ft. to 6 ft. diam. By the end of the first quarter of 1923 a sufficient quantity of full-scale trial results had been collected to permit of an analysis of the leading proportions which resulted from the successful combination of theory and practice. This analysis has rendered possible the standardisation of the features of design to the extent that all ordinary cases in practice can be met from a set of type drawings and patterns.

Description of the Propeller.

The Gill propeller consists of a screw, having two or more blades, which are mounted at their inner ends on a boss, or hub, and fixed at their outer ends to a shroud of special form, surrounding the screw. The shroud contracts in nozzle shape from the forward to the after end of the propeller, and the working pitch of the blades increases axially in the same direction. The blades and the shorud are designed to produce regular acceleration in the stream acted upon, according to the recognised laws of fluid flow. The boss, blades and shroud constitute a complete propeller, and rotate as a unit.

A typical open propeller with a shroud fitted to it would not constitute a satisfactory shrouded propeller, even if the shroud were of good form. In the first place, it would overload the engine to which it had hitherto been suited, and, in the second place, it would lose much of its efficiency. The theoretical considerations affecting the design of the Gill propeller are somewhat complicated, for they have to take into account a great variety of factors. In practice, however, this propeller is made from 10 to 15 per cent. smaller in its determining proportions than is an open screw for the same installation. This is chiefly because all the water which enters a Gill propeller is compelled to go through it in the direction required to produce reaction or thrust, and the propeller, therefore, takes on a more direct load for its size than does the normal type of screw. The same feature serves to furnish a reason for the fact that this propeller gives effective results, even under conditions of obstructed and oblique inflow, in addition to partly accounting for its freedom from vibration, and explaining the remarkable initial acceleration displayed by any vessel to which it is fitted.

The distinguishing feature of this screw, in causing all the water acted upon to be thrust directly astern, is one of great importance, for it is obviously impossible to develop a full forward reaction from water which is thrown out divergently.

Slip.

This introduces the much misunderstood subject of "slip," and it is well to note that a propeller, whose advance through a solid "nut" would be from one and a-quarter to one and one-third times that of the actual forward advance which it makes through the water, is, generally speaking, more efficient than propellers with less so-called "slip." A further notable feature of this propeller is that it produces better results when working under very shallow immersion than do open screws under like conditions, being distinctly less liable to "break surface" than are screws of the open type and being less affected by the air taken down when this does occur. Among

objections which have been advanced, the first is usually the increased frictional surface due to the shroud. This would be valid except for the fact that considerably more useful effect is produced by the shroud than is lost by its surface friction. The next objection frequently raised is that the shroud should preferably be fixed, with the propeller rotating within it. Such an arrangement would be unsound hydraulically on account of excessive eddy losses, and unsound mechanically by reason of the difficulty of maintaining alignment in service.

Another objection put forward is, that solid objects may become wedged in the propeller, but it is found in practice that, if too large to go through, they are thrown off. Further and more far-fetched objections are the centrifugal tendency to bursting of the shroud and the possibility of its acting as a "drogue." These suppositions lose sight of the fact that, owing to the velocity of flow, the internal pressure is much lower than that outside the shroud, while in true nozzle flow the pressure normal to the internal surface of the nozzle has a zero value.

Recent Results.

A recent case in which one of these propellers, of medium size, viz., 10 ft. 6 in. diam., had been applied to a steam-driven vessel of 1,200 i.h.p. with very good results, is that of the salvage ship *Ringdove's Aid,* belonging to the Falmouth Docks & Engineering Company. This vessel is a composite-built ex-naval sloop, almost identical with H.M.S. *Greyhound,* made famous by Mr. W. Froude's classic towing experiments, and very suitable for salvage work. A new and specially-built set of compound engines, by J. Samuel White & Co. Ltd., has recently been installed, and ample propulsive data being available for this vessel, it was calculated that a sea speed of 11 knots was to be expected with the 1,200 i.h.p. and a good four-bladed propeller running at 120 r.p.m. In view of the successful results obtained with Gill propellers as applied to smaller craft in the service of the same company, however, it was decided to fit one to this salvage ship, and the screw was cast in iron at the works of Cox & Co. (Engineers) Ltd., Falmouth, to the design of the Gill Propeller Co. Ltd., 17, Victoria Street, London. A series of trials of the installation was carried out during the first week in July, and it was found that the speed of 11 knots could be attained with about 80 per cent. of the indicated horse-power and 90 per cent. of the revolutions per minute which were calculated as being required for an open screw. It was also found that the ship handled and steered with remarkable ease, even down to the working condition of just "turning over" at 12 r.p.m., while she could be stopped in 70 seconds from ringing down, when running at 10 knots, and showed notably rapid acceleration both "ahead" and "astern." It was also observed that the propeller displayed no tendency to race when breaking surface in heavy swell or to "cant" the ship when going from "ahead" to "astern." The performance of the propeller on this vessel is stated by those who witnessed the trials to be remarkable and conclusive, while it is reported to be equally satisfactory on the emergency service in which the vessel has been subsequently engaged, a speed of 11·5 knots having been attained.

It is also interesting to note that, when fitted to a large steam tug on the Thames, the propeller produced towing and steering results admittedly 5 per cent. better than those attained with the best open propeller, in addition to eliminating the troubles of damage to blades, while when fitted this year to a large motor-driven canal tug at Liverpool, it gave a notably better towing speed than four open propellers of the best makes, previously tried on the same boat, and also proved immune from fouling troubles.

Manœuvring Powers.

The stopping and manœuvring powers developed by the Gill propeller appear to be quite good, and a ship so fitted answers her helm readily down to the lowest speeds. It has also been found to obviate squatting action at the stern and to leave a relatively smooth propeller wake.

The latter should prove a valuable attribute in the case of vessels operating in narrow rivers and canals. The employment of this type of shrouded propeller is not confined to any one class or size of vessel, for it is upheld that its range of utility is considerably wider than that of the open screw.

Its adoption in the case of vessels previously fitted with an open screw or screws does not involve any structural alteration or additional fittings to the hull or power plant, whilst its inclusion for a vessel in the design stage should permit of higher revolution speeds being employed with resulting economy in weight, bulk and cost of propelling machinery.

THE GYROSCOPE AS A SHIP STABILISER.—(*Concluded from page* 344.)

operates from the ship supply, and comes up to full speed of about 6,000 r.p.m. in 15 minutes, without attention other than closing the switch to start it. The moving contact arm mentioned above makes contact to energise either of the two reversing switch coils of the precession motor starter.

An important auxiliary unit of the precession system is the centraliser and limit switch. This is a drum switch, the contactors of which are operated by cams geared to the reduction unit. By shifting the angular position of these cams we are able to fix the relation between the gyro unit and the opening and closing of the switches. Two of these switches are set to open when the gyro precesses about 55 deg. from the vertical. They are in the line of the circuits which energise the precession motor reversing relay switches, and precession will automatically be brought to a stop when one of these switches opens. It is therefore impossible for the gyro to precess much more than 55 to 60 deg. The other two switches close whenever the gyro precesses to the 45 deg. mark. By closing they energise the centraliser coils on the control gyro. These coils operate ratchet and pawl devices to compress or release springs which act against the precession movement of the control gyro unit. If the main stabiliser gyro tends to precess mostly on one side of the vertical, the centraliser will gradually tighten a spring and increase the resistance against movement of the control gyro which causes precession of the main gyro in that direction. The function of the centraliser and limit switch is, therefore, to keep the main gyro precessing in equal arcs each side of the vertical and within limits of 110 deg. and 120 deg. total arc.

Vacuum and Oil Pumps.

The only other important units of the equipment are the vacuum and oil pumps. The former automatically maintains vacuum between 14 in. and 16 in. The latter is used to pump oil to the bearings of the stabiliser. The suction well of this pump is the lower cap of the gyro unit. As explained before, all oil drains from the bearings down to the lower cap of the gyro unit. From here it is drawn up and out of one of the gudgeon bearings by the oil pump, and forced through a cooler and strainer, and back through the other gudgeon to the bearings of the gyro unit. After half speed of the main gyro the gear pump in the lower cap will furnish sufficient oil to take care of the entire equipment. The electric oiling pump may then be stopped, and the oiling system is entirely automatic and needs no attention other than to see that the oil temperature does not rise too high. The oil temperature at the inlet gudgeon should be around 95 deg. to 105 deg. Fahr. This is adjusted by the amount of cooling water through the oil cooler. The oil used is a pure mineral oil of medium heavy grade having a viscosity of 130 saybolt seconds at 100 deg. Fahr.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

The Salving of Ships.

Ship salvage in times passed was almost exclusively in the hands of nautical people. Nowadays it is becoming an increasingly technical operation and many mechanical devices and methods have been prepared which call for great skill and knowledge on the part of the salvor. The subject has many aspects and thus exceedingly different artifices have to be made use of depending upon the nature of the wreck to be salved. The author of this article outlines the principal aspects of the subject, and suggests that the organisation of a salvage company must be drawn up to provide for these aspects.

As with every other industrial operation it is necessary both to have experience and to profit by it. To this end the author has compiled a very comprehensive list of salvages which have been described in the technical press during the last twenty years or so. This list describes in tabular form the principal features of each case, such as location and nature of shore, nature of ship damage, salvage method employed, &c. This list, which comprises details of practically 150 wrecks, together with the reference giving the source of information, should prove especially valuable to ship salvors. For any contemplated salvage the list enables similar cases to be rapidly traced and thus the experience of these to be utilised.

The pecuniary reward of the salvor belongs to that unfortunate class "no cure no pay," and it is only by a more systematic and comprehensive study of the technique and experience of the subject that companies can continue to exist and pay consistent dividends.

This article forms a contribution to the more scientific study of the subject.—*E. Oppenheimer, Werft, Reederei, Hafen*, July 7, 1923, p. 365; 6 pp.

The Resistance and Propulsion of Ships.

In our January and June notes we have referred to previous articles of this series. In this article Professor Rudloff deals with the very important question of the characteristics of a vessel's fineness of form by means of coefficients. First of all he states his preference for $\frac{L}{\Delta^{\frac{1}{3}}}$ instead of $\frac{L}{B}$. Here, of course, he follows Froude. Next, the expression $\frac{B}{L}\phi$, proposed many years ago by Johow as the mean tangent of waterplanes, is examined. Professor Rudloff shows that this expression does not represent the mean tangent, and shows in a very interesting manner that this is really expressed by $\frac{B}{L}\beta$ where β is the midship coefficient. This expression corresponds to angles of from 18 to 9 deg. in the case of battleships and torpedo-boats. Next, the alternative expression $\beta \frac{\Delta^{\frac{1}{3}}}{L}$ is proposed, and this is again assumed to represent the tangent of an angle. (Professor Rudloff gives no justification for this step. The expression does not represent the tangent of an angle, but really is the midship section area of a 1-ton model multiplied by its block coefficient. This can but coarsely represent fineness if at all. A similar remark may be passed with regard to the alternative expression $\frac{B}{L}\beta$.)

Next, a brief reference to model experiment work is made. Baker's work is quoted to show that for values of $\frac{V}{\sqrt{e}}$ less than unity the midship section may be high and approaching 0·99, whilst for speed ratios greater than unity lower values of β must be used. General considerations of the design of lines are also briefly referred to, and finally the importance of the careful study of research work is emphasised.

The final article deals with the definition and determination of economical speed. Various definitions of this speed exist. "Purely technically it is to be understood as the speed at which over a given distance a vessel has the smallest coal consumption." This definition the author subsequently corrects by introducing crew expenses, and pointing out that a minimum steerage speed exists. Next the old (arbitrary ?) definition of economic speed as that at which a vessel's wave making and frictional resistances are equal is revived. This criterion, it is shown, results in the indicated power of a 10-knot vessel varying as 3·25 power of the speed at the limiting economic speed. The corresponding values of the admiralty constant and the coefficient obtained by substituting the wetted surface for the displacement is two-thirds power in the foregoing are examined for a few cases.

Some attention is given to the economical speeds of warships, and finally the importance of model experiments in solving the many problems in the economic propulsion of ships is emphasised.—*Prof. Rudloff, Schiffbau*, July 25, 1923; p. 681; 4 pp.

The Loading and Discharging of Ships.

The necessity for the more rapid loading and discharging of ships has been repeatedly emphasised. When it is remembered that on European trade a merchant vessel only spends about 40 to 50 per cent. of its life at sea, on Asiatic trade only 50 to 60 per cent., and that 65 per cent. is about the maximum for any trade, then the economic importance of developing better loading and discharging methods is self-evident. These methods must be improved on the ship itself as well as in the ports. Thus attention must be given to the method of loading. The vessel must be appropriate to its trade. The German-Russian locomotive transport vessels are cited as a good instance of what can be done in this direction (see Foreign Notes, January, 1923, p. 35). The container transport barge is another good example of the observance of this principle (see Foreign Notes, July, 1923). An American efficiency engineer has pointed out that all horizontal transport in a ship hold is useless, and that as far as possible the only motions should be vertical, *i.e.*, the cargo should be capable of being dropped straight in or lifted straight out. He estimates that the horizontal motions take up six times the time of the useful vertical motions. To remedy this state of affairs large and wide hatches are essential. This is particularly observed in the case of the various patented self-trimming vessels. Finally, the author considers harbour improvements and naturally recommends the close collaboration of shipowner and dock authority. The transport facilities on the American lakes are cited as a good example of what may be accomplished in this respect. In this connection the development of ore-carrying vessels and Hulett ore-discharging grabs are outlined. With the use of the latter a 10,000-ton ore-carrier has been discharged in 2½ hours.—*F. Muller van Brakel, Het Schip*, June 29, 1923, p. 157; 2 pp.; 5 ff.

Liquid Fuel and its Combustion in Diesel Engines.

This article forms a very comprehensive survey of the subject. It is pointed out that fundamentally the engine can either be designed to satisfy the peculiarities of the fuel or the fuel can be constituted to satisfy the peculiarities or limitations of an engine. Research has been made in both these directions, but, of course, chiefly in the former.

The importance of a thorough knowledge of the chemical and physical properties of the various oils cannot be over-estimated, and the major portion of the article under review is devoted to this end, the treatment being chiefly from the Diesel engineer's point of view.

Next, the author considers the whole regime of fuel transformation in Diesel engines and deals very thoroughly with the following phases: injection, atomisation, explosion and combustion. Very comprehensive references are given throughout, and several interesting comparisons with British research are made. In particular, the apparatus used by Krupp, for the determination of the flash point of various fuels is described and the results compared with other German and British work. The difference between the flash points thus determined and those experienced in the working of actual Diesel engines is emphasised. In this connection the work of Prof. Hawkes is referred to. Finally, the pioneer work of Holms in connection with the practical importance of flash point determination and its relation to the chemical constitution of the fuel is acknowledged. *Oberingenieur O. Alt, Zeitschrift des V. d. I.*, July 14, 1923; p. 686; 6 pp.; 13 ff.

Motor Ship Engine-Room Ventilation.

A comparison of a marine motor installation with its correspondingly equivalent steam installation reveals the fact that with the former heat radiation is much more possible, and hence much more prevalent. This fact alone should necessitate better engine-room ventilation, but when the pollution of the atmosphere, due to evaporated lubricating oil, is considered, the case for adequate ventilation is made evident. The gases from the lubricating oil can be eliminated to a certain extent by better jointing of flanges all round, but this does not solve the difficulty absolutely. More liberal bearing surfaces with a consequent reduction of heat produced by friction can be adopted with profit, but considerations of absolute size of engine limit the possibilities of this method. Gas leakages can be easily discovered by manometers. Bad ventilation shows itself by the deposit of greasy matter all over the engine room. One of the best means to assist ventilation is by fitting a cooling apparatus the whole length of the engine room. Naturally, a roomy skylight and an ample number of cool ventilators are absolutely essential.—"*S.G.B.*," *Het. Schip*, August 10, 1923; p. 196; 1 pp.

Research Work at the Hamburg Experiment Tank.

At the recent annual meeting of the *Gesellschaft der Freunde und Forderer der Hamburgischen Schiffbauversuchsanstalt*, the members were treated to some interesting vistas of the research at present being undertaken at the tank. Research on contra propellers, bulge-formed vessels, and the Flettner rudder has been frequently referred to and need not be elaborated here. Other and not so well-known developments are the following. Further research on the bulge form is enabling still further economy to be affected, and in addition to the *Albert Ballin* and *Deutschland*, five other vessels at present under construction on the Weser are to be of this type.

A new form of after body for twin-screw vessels is being experimented upon. This form consists essentially of a double stern, each screw having its own stern post and the intervening hull running up at angle to the poop. Two rudders are fitted to the vessel and it is being found that the flow of water to the propellers is being materially improved.

The Flettner rudder, as fitted to the *Odenwald*, has been developed, and a new type consisting of three auxiliary rudders to each main rudder has been successfully experimented upon.

Herr Flettner, the inventor of this rudder, has also directed his attention to the possibilities of the sailing ship, and there is at present under construction a vessel which is to be fitted with metallic sails. These sails will be controlled in a similar manner to the Flettner rudder, *i.e.*, by flap sails. The vessels' masts and sails have no rigging and thus the considerable air resistance of this latter is eliminated. The trial trip of this vessel will be awaited with interest.—*Hansa*, July 28, 1923; p. 804; 2 pp.

The Application of Polar Co-ordinates to Shipbuilding Calculations.

The manner in which various shipbuilding calculations have evolved has produced a range of distinct calculations. The desire to know a vessel's carrying capacity first led to the calculation of the displacement in the upright condition. As technique developed, its potency as an instrument of design became appreciated and the calculation of initial stability and that over a range inclination was carried out. In the early days this investigation was restricted to the load displacement, the considerable amount of work involved (*e.g.*, Barnes' method) being the principal cause of the restriction. However, with the introduction of the integrator, it became customary to investigate a vessel's stability over a large range of displacement and inclination.

Similarly, it has become customary to carry out trim, bilging and launching calculations, all, however, by quite distinct methods.

The author points out that all these calculations depend fundamentally upon the complete knowledge of a vessel's displacement and centres of buoyancy at all draughts and longitudinal and transverse inclinations. He thus proposes to determine completely in the first place all these quantities by the application of polar co-ordinates. A fully illustrated example is worked out culminating in the portrayal of the complete form history of the vessel, in terms of draught and longitudinal and transverse angles of inclination. With this information, any of the ordinary calculations can be rapidly performed. Bilging calculations and floodable length calculations become especially simple and a particular example is given. Stability calculations are materially simplified. The requisite data for launching calculations can also be simply taken from these general data, and an example is given illustrating the application.

The proposal is a valuable one and is worthy of adoption.—*Prof. Herner, Werft, Reederei, Hafen*, August 7, 1923; p. 415; 6 pp. 15 ff.

The Proposed Norwegian Experiment Tank.

Proposals for a Norwegian experiment tank to be attached to the Trondhjem High School were first made in December, 1913, and since that date schemes have been taking a more definite and realisable shape.

This preliminary article deals first of all with the development and possibilities of model experiment technique. The pioneer work of Chapman, Beaufoy and early French investigators is rapidly reviewed, and attention is chiefly directed to the work of the Froudes and their methods as evidenced in all existing experiment tanks of the present day.

Sizes of ship and propeller models, method of manufacture and sizes of tanks themselves, are discussed. On the advice of Professor Mørch, who specially visited the Berlin, Hamburg and Vienna tanks, the Norwegian tank has to have the following dimensions over the water surface:—Length, 182·5 metres; breadth, 11 metres; depth, 5·75 metres. In addition, a smaller tank working on the Welkenkaop principle is to be built, having the following dimensions:—Length, 25 metres; breadth, 2 metres; depth, 1·25 metres.

An interesting table giving particulars of 20 completed tanks and the proposed Dutch and Norwegian tanks is supplied.

The Norwegian tank is to have a model wagon capable of a speed of 9 m/sec. and dealing with wood or paraffin models up to 8 metres in length.

According to the most recent estimate, the cost of the whole proposition will be 1,650,000 kr. Some considerable difficulty is being experienced in getting permission from the Exchequer to commence building. Apparently this department wish that the Physics Laboratory at present under construction at the Trondhjem High School should be completed first. To accomplish this they propose to borrow the money already subscribed by Norwegian shipowners and shipbuilders for the tank. (To be continued.)—*Skibsbygning*. Nos. 3 and 4, 1923; 7 pp.; 1 ff.

The Solid Injection High-Pressure Oil Engine.

Although this article deals more particularly with the Hesselman engine, many interesting remarks relevant to air *versus* solid injection are contained in it.

Injection air has a triple duty: to introduce the fuel gradually in to the cylinder, to atomise the fuel and to mix it thoroughly and rapidly with the combustion air. The first item is generally satisfactorily, although by no means completely carried out. For instance, at low loads the correct introduction of the fuel is uncertain, for rapidly changing loads necessitates corresponding variation in the injection air pressure. Atomisation is excellently carried out by air injection. The mixing of air and fuel is also satisfactory, although the low temperature of the injection air brings certain disadvantages and the turbulence of gases in the cylinder increases the heat loss in the walls.

Solid injection has the big advantage of dispensing with the compressor, and thus, apart from anything else, we have mechanical simplicity and the elimination of the cooling effect of injection air. Mechanical or solid injection besides eliminating the compressor work also increases the mechanical efficiency. However, it is not always remembered that a part of the compressor work is regained through the expansion of the injection air in the cylinder, so that generally the maximum gain in mechanical efficiency will amount to 3 to 4 per cent. at the most. The useful work done in the cylinder by the injection air has as a result a clearly indicated improved fuel consumption. Since this is often regarded as a measure of the combustion efficiency it should not be forgotten that for the same fuel consumption per i.h.p.-hour, the combustion with mechanical injection is 3 to 5 per cent. more efficient than with air injection.

The chief difficulty of mechanical injection is to introduce the fuel into the cylinder without a marked increase in pressure and at the same time ensure its being well mixed with the air. A fuel pump overcoming these difficulties has been produced by the author and embodied in the Hesselman engine and is described in considerable detail. Other details of the Hesselman engine, such as fuel valve, atomisation and test results, are dealt with at length.—*K. S. E. Hesselman, Zeitschrift des V. d. I.*, July 7, 1923; p. 658; 5 pp.; 16 ff.

RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

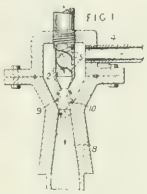
No. 197,654. Turbines.

Akt.-Ges. Brown, Boveri, et Cie, Baden, Switzerland. April 3, 1923, *No.* 9195. *Convention date, May* 15, 1922. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 110 (iii).]

To improve the efficiency of existing turbine installations, the pressure and (or) the superheat of the steam is increased and the additional available heat-drop is utilised in a turbine placed before the high-pressure stage of the existing turbines. A single additional turbine may be placed before several existing turbines in parallel and several additional turbines in parallel may be placed before a single existing turbine. The additional turbine may supply power independently of the existing turbine or may be geared to it.

No. 197,684. Ejectors.

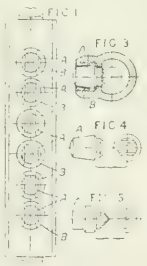
Kobüdke, A. M., Gilderoy, Victoria, Australia. May 10, 1923, *No.* 12583. *Convention date, May* 10, 1922. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 71.]



The nozzle 2 of a steam or water-operated ejector for producing a vacuum in a chamber connected therewith through a pipe 4 is provided with a spiral baffle 5 or with internal spiral ribs, not shown, so that the inducing fluid is thereby given a rotary motion and issues therefrom as a wall 9 enclosing a space 10 into which the air is sucked from the chamber to be evacuated. The exhaust pipe 8 may be given a drop of 33 ft. so that the exhaust serves also as an ejector.

No. 197,895. Boiler Gauge Glasses, &c.

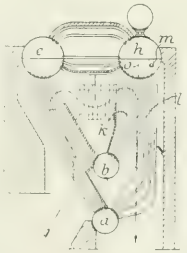
Boizard, R., 11, *Boulevard St. Germain, Paris. January* 5, 1923, *No.* 454. *Convention date, August* 11, 1922. [*Class* 123 (i).]



A reflector gauge glass for high-pressure boilers and other apparatus is distinguished by a series of small reflector glasses of variable form and cut arranged as desired on the body of the gauge. In Fig. 1, the reflectors A are shown arranged vertically but they may be staggered or otherwise arranged. Each reflector is secured by a nut B, Fig. 3. Figs. 4 and 5 show ways of cutting the reflector glasses.

No. 197,877. Water-tube Boilers.

Stirling Boiler Company Limited, 54, *Victoria Street, Westminster.*—(*Deutsche Babcock & Wilcox Dampfkessel- Werke, Akt.-Ges., Oberhausen, Rhineland, Germany.*) *August* 8, 1922, *No.* 21558. [*Class* 123 (ii).]

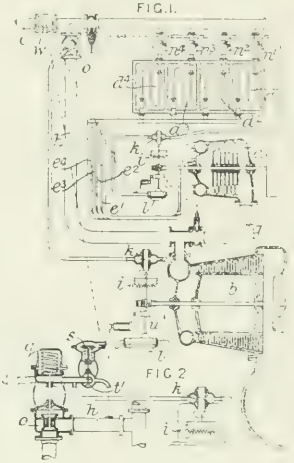


In a water-tube boiler having two separate circulation currents between upper drums *e*, *h* and lower drums *b*, *a*, and a common circulation between the upper drums, the tubes in the paths of the separate circulation currents being substantially parallel, the feed inlet *m* is so placed in the rear drum as to feed the water mainly to the outer circulation current. A partition *o* is fitted in the rear drum between the ends of the two groups of down-take tubes *l*, *k*.

No. 197,673. Turbines

Akt.-Ges. Brown, Boveri, et Cie, Baden, Switzerland. May 4, 1923, *No.* 12069. *Convention date, May* 13, 1922. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 110 (iii).]

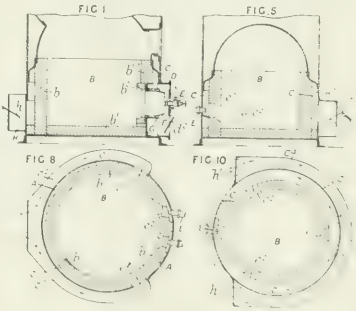
Motor power plant; regulating; working-fluid supply.—A turbine installation using high pressures and high superheat comprises a small high-pressure turbine *a* specially designed to withstand high temperatures, receiving steam at say 460-500° C., and a low-pressure turbine *b* which is built according to standard practice and receives steam from the exhaust pipe *g* of the turbine *a* at moderate superheat temperatures, say 300-350° C. Auxiliary live steam at moderate temperatures may be supplied by a valve *o* and pipe *h* to the low-pressure turbine *b*, which may be run independently when the turbine *a* is shut down. The turbine *b* is designed to take over two-thirds to three-quarters of the total output of the set. Steam is led to the turbine *a* from the pipe *c* by way of the high superheaters d^1 . . d^4, each with its own valve n^1 . . n^4, and the pipes e^1 . . e^4. The regulating valves *o*, n^1 . . n^4 are actuated by pistons subjected to oil pressure supplied by pumps *l* through valves *k* adjusted by centrifugal governors *i*. Safety governors *u* are provided to shut down quickly a valve *w* in the event of excessive speed. To obviate too great a load on the low-pressure turbine, the oil under the piston *q*, Fig. 2, of the valve *o* may be allowed to escape by way of a small valve l^1, which is opened by excessive pressure in the pipe *h* acting on a diaphragm *s*, the valve *o* being thereupon closed.



No. 199,065. Furnaces.

Kermode, J. J., 35, *The Temple, Dale Street, Liverpool. February* 13, 1922. *No.* 4135. [*Class* 51 (i).]

Liquid fuel furnaces.—In a vertical boiler fired with liquid fuel, the combustion chamber B (Fig. 1) is formed by a refractory lining b^1 separated from the boiler shell by an annular space C, in which air supplied to the combustion chamber is heated. Air enters the space C through a non-return valve h^1 provided in a casing H, and passes into a casing D surrounding the burner E and provided with a non-return air-admission valve d^2. An adjustable cone F, casing G, and refractory extension b^2 are also provided within the casing D and opening leading to the combustion chamber. The rear portion of the lining b^1 may be carried upwardly and forwardly to form a deflector for the gases. According to a modification, the air enters the space C through a valve at the rear of the furnace and passes directly into the combustion chamber B through lateral openings near the front. In the modification shown in Fig. 5, the burner casing

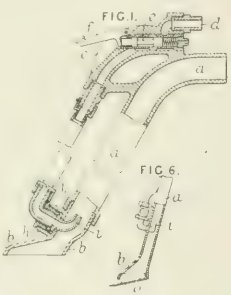


is dispensed with, the burner E being mounted on the boiler shell in front of an opening e^2. Air enters the casing H^2 through a non-return valve h^1 controlled by a regulating screw h^4 and passes into the annular space C leading into the combustion chamber through openings e^2. Fig. 8 shows a modification in which the lining b^1 is separated from the boiler shell by a "dead" space C^1, and the air is heated in an annular duct C^2 formed outside the boiler shell and communicating with the combustion chamber through openings c^2. This arrangement may be modified by providing passages in the shell A so that air heated in the space C^1 may pass into the space C^2. In the modification shown in Fig. 10, air enters through valves h^1 an annular space C^4 formed on the outside of the boiler shell and passes through openings c^5 into the annular space C and thence through openings c^2 to the combustion chamber. A preliminary heating of the air before it enters the annular passages surrounding the combustion chamber may be effected in a casing enclosing the bottom of the combustion chamber. Specifications 104,356 and 156,834 are referred to.

No. 199,090. Ejectors for Ships' Tanks, &c.

Thompson, H. A., 9, *Cleveland Terrace, North Shields, Northumberland. March* 10, 1922, *No.* 7109. [*Classes* 8 (i), 71, *and* 113 (i).]

An ejector suction apparatus for removing liquid refuse from tanks, &c., on ships consists of a rigid tubular member within which a suction is set up by means of a central conical or annular steam or air nozzle; it is adapted to form a handle, or is fitted with a hand-grip, and the lower end tube has preferably a squeegee or scraper such as those described in Specification 199,338. The tubular member *a* (Fig. 1), with suction mouth piece *b* below and handle *c* above associated with the inducing-fluid supply connection *d* and the thumb-operated control valve parts *f*, *e*, has a lateral socket *h* carrying the central upwardly directed inducing-fluid nozzle *i*. In a modification (Fig. 6) the mouthpiece *b* is fitted with a steel scraper *o* whereby material adhering to the walls of the tank, &c., to be emptied may be removed.



No. 199,180. Turbines.

British Thomson-Houston Company Limited, Crown House, Aldwych, London.—(General Electric Company, Schenectady, New York, U.S.A.) April 4, 1922, *No.* 9680. [*Class* 110 (iii).]

Blades and spacing blocks are tightly assembled in a groove in a member which is subsequently mounted on the rotor, and the edges of the groove are turned over the spacing blocks. The blades 14 (Fig. 3) are formed with tenons 16 to enter holes in the shrouding strips, and have projections 14^a formed with a suitable tool and adapted to bite into the edges of adjacent spacing members 15 (Fig. 4) when these are hammered tightly into place in a groove 11 in a member 10 adapted subsequently to be finished to a T-section and secured to a rotor, as shown in Fig. 9. The edges 13 (Fig. 2) of the groove 11 are turned over the spacing blocks and the whole united by fusion metal preferably by the method described in Specification 158,565, or by any other method. A shrouding strip 32 (Fig. 9) is mounted by turning over the tenons on the blades or by welding shorter tenons in the holes in the shrouding strips. The grooved member 10 (Fig. 2) and the assembled blades may be in segmental form or in complete ring form for attachment to a rotor.

No. 199,365. Steam Generators.

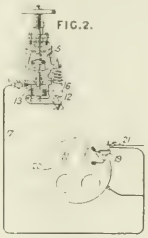
Marquerre, F., 27, *Collinistrasse, Mannheim, Germany. May* 8, 1923, *No.* 12345. *Convention date, June* 15, 1922. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 123 (ii).]

Generating by reduction of pressure of heated water; generating by direct contact of steam with boiler water.—Relates to a process for storing energy wherein water in a container is evaporated during the storing period by reduction of pressure, the steam generated being compressed and stored for use in an engine the exhaust from which is led into the container. According to the invention, "only that part of the water which is required for the transmission of heat by the compressor in the form of steam is conducted to the storing boiler, while the remainder of the water is conducted by other means into the storing boiler." Part of the water in the container is pumped directly into the storing boiler. This water may be used for cooling the compressor.

No. 199,304. Steam-boilers; Valves.

Aster Engineering Company (1913) *Limited, Wembley, and Smith, W., Bruce Cottage, Byron Hill Road, Harrow, both in Middlesex. September* 20, 1922, *No.* 25491. [*Classes* 123 (ii) *and* 135.]

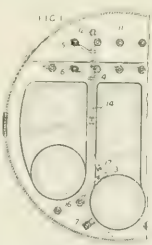
Feed-water, controlling.—Relates to apparatus of the kind in which a valve such as the suction or the steam valve of the feed pump is controlled by a piston or the like pressure-operated device, the supply of pressure fluid to the device being so regulated in accordance with the boiler water level that when the level falls the device moves the valve to such a position that water is supplied to the boiler. According to the invention, the conduit 17, which supplies pressure fluid from a boiler 20 to piston or like device 12, has an outlet 21 through which, normally, the fluid leaks, the outlet being closed by a float valve 19 when the boiler water falls below a certain level. The pressure fluid forces the piston downwards against the tension of a spring 16, thus moving a rod 13 out of contact with the pump suction valve 5. In modifications, the rod is secured to a rotary valve controlling the steam supply to the feed pump or injector.



No. 199,317. Steam Boilers.

Brown, R., 76, *Barfillan Drive, Cardonald, Glasgow. October* 23, 1922, *No.* 28729. [*Class* 123 (ii).]

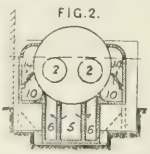
Water circulation, apparatus for promoting.—A primary local circulation is set up in the water confined within an open-mouthed collector arranged close to the crown of the furnace before the main circulation can be set up to discharge water from the apparatus above the water level. A casing 4 clamped to the stays 5, 6 extends into the steam space 11, its top being closed by a cap 12. The lower end has a glazed collector 13 arranged close to the furnace crown and receives the nozzle 17 of the dip pipe 16 clamped to the stay 7. A branch 14 of the casing 4 extends from well below the water line to just above the normal water level and terminates in a goose-neck. In a modification, the lower end of the casing 4 is bifurcated so as to serve the crowns of adjacent furnaces.



No. 199,562. Steam-boiler Settings.

Priestley, A., Grove Mills, Ovenden, Halifax, Yorkshire. May 10, 1922, *No.* 13138. [*Class* 123 (ii).]

Settings of Lancashire and Cornish boilers are constructed so that the gases from the furnace tubes 2 pass to the front of the boiler through a central flue 5, and are single, then divided into two streams to pass through superimposed flues 6, 10, 14 arranged on each side of the boiler. The flues 14 have damper controlled outlets communicating with the chimney.



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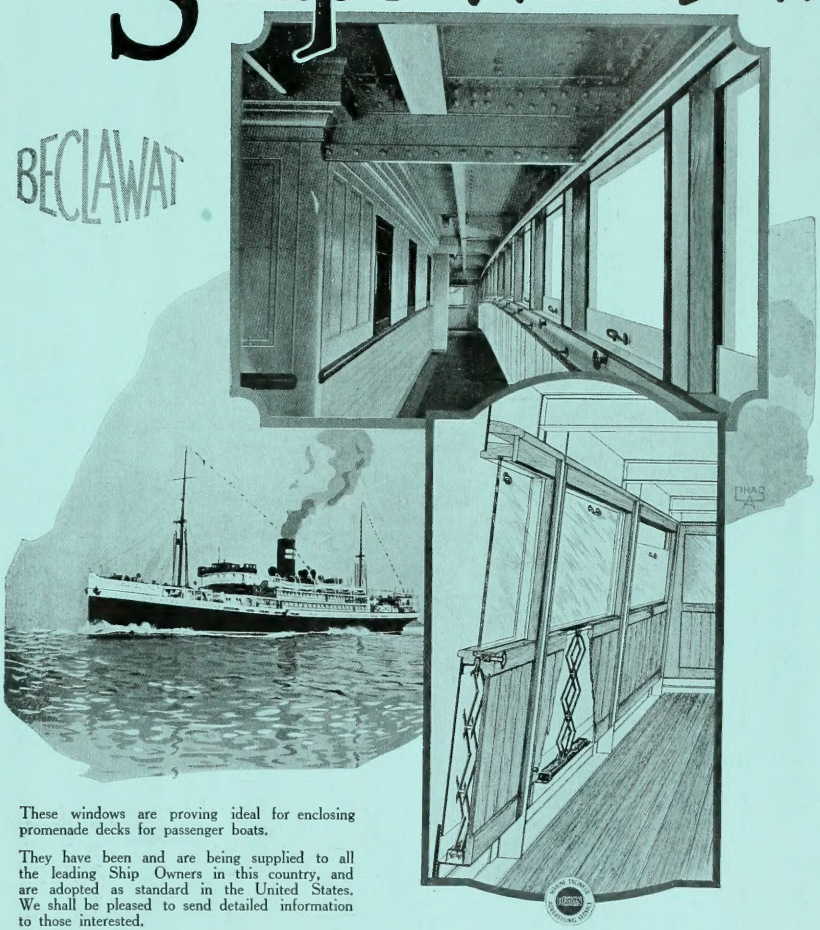

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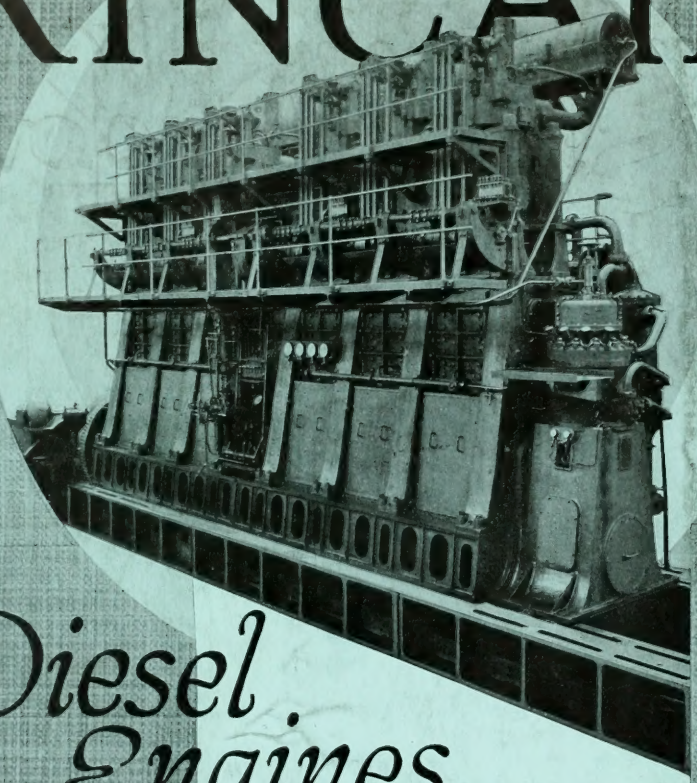

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